

CBO

An Analysis of the Navy's Fiscal Year 2019 Shipbuilding Plan



OCTOBER 2018

At a Glance

As directed by the Congress, every year the Navy submits a report with the President's budget that describes the planned inventory, purchases, deliveries, and retirements of the ships in its fleet for the next 30 years. In this report, the Congressional Budget Office analyzes the Navy's fiscal year 2019 shipbuilding plan and estimates the costs of implementing it.

- **Inventory.** The Navy currently has 285 battle force ships, but it aims to build and maintain a 355-ship force.
- **Purchasing Plan.** The Navy plans to purchase 301 new ships between 2019 and 2048: 245 combat ships and 56 support ships. If the Navy adheres to the schedule for retiring ships outlined in the 2019 plan, it would not meet its goal of 355 ships at any time over the next 30 years.
- **Fleet Size.** After releasing its shipbuilding plan, the Navy announced that it would extend the service life of its destroyers from 35 or 40 years to 45 years and that it would extend the service life of up to 7 attack submarines from 33 to 43 years. With those service life extensions, the fleet would reach 355 ships in 2034 but would fall short of the Navy's specific goals for some types of ships.
- **Fleet Cost.** Buying the new ships would cost an average of \$26.7 billion per year in 2018 dollars, CBO estimates. If all costs associated with the Navy's shipbuilding budget are included, such as the cost of refueling nuclear-powered aircraft carriers or outfitting new ships with various small pieces of equipment after they are built, CBO estimates that the total shipbuilding budget would average \$28.9 billion per year, one-third more than the Navy's estimate.
- **Comparison With Previous Budgets.** That total is 80 percent more than the average shipbuilding budget the Navy has received over the past 30 years and about 50 percent more than the average budget of the past 6 years, a period of increasing shipbuilding appropriations.



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Unless otherwise indicated, all years referred to in this document are federal fiscal years, which run from October 1 to September 30 and are designated by the calendar year in which they end; all dollar amounts reflect budget authority in 2018 dollars.

Numbers in the text and tables may not add up to totals because of rounding.

The data underlying the figures are posted with the report on CBO's website.

On the cover:

Top left: Seawolf class attack submarine USS *Connecticut* (SSN-22). U.S. Navy photo by Thiep Van Nguyen II.

Top right: The Arleigh Burke class guided missile destroyers USS *Stockdale* (DDG-106), USS *Shoup* (DDG-86), and USS *John Paul Jones* (DDG-53). U.S. Navy photo by Mass Communication Specialist 2nd Class Benjamin Crossley.

Bottom left: The lead ship of the San Antonio class amphibious transport dock ship, the USS *San Antonio* (LPD-17). U.S. Navy photo by Mass Communication Specialist 3rd Class Sabrina Fine.

Bottom right: The Nimitz class aircraft carrier USS *George Washington* (CVN-73). U.S. Navy photo by Mass Communication Specialist 3rd Class Chris Cavagnaro.



An Analysis of the Navy's Fiscal Year 2019 Shipbuilding Plan

Summary

The Department of Defense (DoD) submitted the Navy's 2019 shipbuilding plan, which covers fiscal years 2019 to 2048, to the Congress in February 2018.¹ The average annual cost of carrying out that plan over the next 30 years would be about \$28.9 billion in 2018 dollars, the Congressional Budget Office estimates. The Navy's 2019 shipbuilding plan differs substantially from its 2017 plan in its goal for the total inventory of battle force ships, the number and types of ships that the Navy would purchase, and the funding proposed to implement the plan.² If fully carried out, the shipbuilding plan would represent the largest naval buildup since the Reagan Administration in the 1980s.

The Navy's 2019 Plan Aims to Expand the Fleet to 355 Battle Force Ships

In September 2018, the Navy's fleet numbered 285 battle force ships—aircraft carriers, submarines, surface combatants, amphibious ships, combat logistics ships, and some support ships. The Navy's goal (in military parlance, its requirement), as stated in its 2019 shipbuilding plan and reflecting its 2016 force structure assessment, is to build and maintain a fleet of 355 battle force ships.³ Toward that goal, the Navy would buy 301 ships over the 2019–2048 period: 245 combat ships and 56 combat logistics and support ships (see Table 1). If the Navy adhered to the schedule for retiring ships outlined in the 2019 plan, however, it would not meet the goal of 355 ships at any time over the next 30 years.

In testimony on April 12, 2018, two months after the Navy released its 2019 plan, senior Navy officials told the Congress that the Navy intends to extend the service life of all DDG-51 destroyers to 45 years, 5 to 10 years longer than indicated in the 2019 and earlier shipbuilding plans. It also expects to extend the life of up to 7 Los Angeles class submarines from 33 years to about 43 years. Together, the 2019 plan and the service life extensions would allow the Navy to reach a 355-ship fleet by 2034, although it would fall short of the specific goals for some types of ships that were identified in the Navy's 2016 force structure assessment. As those developments illustrate, the size of the Navy does not depend on ship construction alone; the length of time that particular ships remain in the fleet also affects the force structure.⁴ (See Table 2 for the composition of the fleet and the planned service life of the major types of ships, and see Box 1 for a description of the major types of ships.)

CBO Estimates That Funding for New Ships in the Navy's Plan Would Average \$26.7 Billion per Year

The Navy estimates that buying the new ships specified in the 2019 plan would cost \$631 billion (in 2018 dollars) over 30 years, or an average of \$21.0 billion per year—\$3.3 billion more per year than the Navy estimated new-ship construction would cost under its 2017 plan. Using its own models and assumptions, CBO estimates that those new ships would cost \$801 billion (in 2018 dollars) over 30 years, or an average of \$26.7 billion per year.⁵

1. Department of the Navy, *Report to Congress on the Annual Long-Range Plan for Construction of Naval Vessels for Fiscal Year 2019* (February 2018), <http://tinyurl.com/y9s4pouj> (PDF, 979 KB).

2. The Navy did not publish a 2018 plan.

3. Department of the Navy, *Executive Summary, 2016 Navy Force Structure Assessment (FSA)* (December 2016), <http://tinyurl.com/zgdk5o7>.

4. For an analysis comparing an alternative that relies on new construction alone with one that makes substantial use of ship service life extensions, see Congressional Budget Office, *Comparing a 355-Ship Fleet With Smaller Naval Forces* (March 2018), www.cbo.gov/publication/53637.

5. For more information on how CBO estimates the costs of future ships, see Congressional Budget Office, *How CBO Estimates the Costs of New Ships* (April 2018), www.cbo.gov/publication/53785.

Table 1.

The Navy's 2017 and 2019 Shipbuilding Plans

	2017 Plan (2017–2046)	2019 Plan (2019–2048)	Change From 2017 to 2019
Number of Ships Purchased Over 30 Years			
Combat Ships			
Aircraft carriers	6	7	1
Ballistic missile submarines	12	12	0
Large payload submarines	0	5	5
Attack submarines	44	60	16
Large surface combatants	66	76	10
Small surface combatants	58	57	-1
Amphibious warfare ships	23	28	5
Subtotal	209	245	36
Combat Logistics and Support Ships	45	56	11
Total	254	301	47
Cost of New-Ship Construction^a (Billions of 2018 dollars)			
Total Cost Over 30 Years			
Navy's estimate	532	631	99
CBO's estimate	593	801	208
Average Annual Cost			
Navy's estimate	17.7	21.0	3.3
CBO's estimate	19.8	26.7	6.9
Average Cost per Ship			
Navy's estimate	2.1	2.1	0
CBO's estimate	2.3	2.7	0.4
Memorandum:			
Average Annual Costs of All Activities Typically Funded From Budget Accounts for Ship Construction			
Navy's estimate	19.6	23.2	3.6
CBO's estimate	21.7	28.9	7.2

Source: Congressional Budget Office, using data from the Department of the Navy.

The Navy did not release a 2018 plan.

a. Costs exclude funds for refueling nuclear-powered aircraft carriers and for ship conversions, construction of ships that are not part of the Navy's battle force (such as oceanographic survey ships) and training ships, outfitting and postdelivery activities (including the purchase of smaller tools and pieces of equipment that are needed to operate a ship but that are not necessarily provided by the manufacturing shipyard as part of ship construction), and smaller items. The costs of the mission packages for littoral combat ships, which are not funded by the Navy's shipbuilding accounts, are also excluded.

CBO's estimates are higher than the Navy's because CBO and the Navy made different assumptions about the design and capabilities of some future ships, used different estimating methods, and treated growth in shipbuilding labor and materials costs differently. Much of the difference between the estimates stems from

uncertainty about the design and capabilities of large ships being built 10 or 20 years from now—especially for two large shipbuilding programs in the 2030s and 2040s. That difference widens over time in part because the Navy's method of developing constant-dollar estimates for most of its shipbuilding programs does not account

for the faster growth in the costs of labor and materials in the shipbuilding industry than in the economy as a whole (see Figure 1). As a result, the Navy's estimate does not reflect the increase in the real (inflation-adjusted) costs of ships with today's capabilities that would be anticipated if such ships were purchased in the future.

The Navy's shipbuilding plan also reports only the costs of new-ship construction. It excludes other activities typically funded from the Navy's budget account for ship construction that would, in CBO's estimate, add \$2.1 billion to the Navy's average annual shipbuilding costs under the 2019 plan.

The Navy's Shipbuilding Plan for the Next 30 Years Would Cost 80 Percent More per Year Than It Has Received in Appropriations Over the Past 30 Years

If the Navy received the same average annual amount of funding (in constant dollars) for ship construction in each of the next 30 years that it has received over the past three decades, the service would not be able to afford its 2019 plan. CBO's estimate of \$26.7 billion per year for new-ship construction under the Navy's 2019 shipbuilding plan is almost double the historical average of \$13.6 billion (in 2018 dollars). CBO's estimate of \$28.9 billion per year for the full cost of the plan is 80 percent higher than the \$15.8 billion the Navy has received in annual appropriations, on average, over the past 30 years for all activities funded by its shipbuilding account.⁶

The 30-year historical average includes the relatively small, post–Cold War shipbuilding budgets of the 1990s. Compared with shipbuilding budgets of the past 6 years—a period of relatively large shipbuilding appropriations—the Navy's plan would still require an increase of more than 50 percent, on average. (Since 2013, the Congress has appropriated \$1 billion to \$3 billion more per year than the President's request, partly as a result of concerns that the fleet is too small to perform all the missions assigned to it; see Figure 2 on page 7.)

6. For an example of how large a fleet the Navy could build if funding continued at its 30-year average, see Congressional Budget Office, *Comparing a 355-Ship Fleet With Smaller Naval Forces* (March 2018), www.cbo.gov/publication/53637.

Table 2.

The Navy's Inventory of Ships and Their Expected Service Life, by Major Ship Type, as of September 2018

	Inventory	Service Life (Years)
Aircraft Carriers	11	50
Ballistic Missile Submarines	14	42
Guided Missile Submarines	4	42
Attack Submarines	50	33–43
Large Surface Combatants	88	35–45
Small Surface Combatants and Mine Countermeasures Ships	27	25–30
Amphibious Ships	32	40
Combat Logistics and Support Ships	59	30–45
Total	285	

Source: Congressional Budget Office, using data from the Department of the Navy.

A Larger Fleet Would Cost More to Operate

CBO did not include operation and support costs for a 355-ship fleet or the cost of extending the service life of the destroyers and submarines. Although the cost of extending the ships' service life is relatively small compared with the cost of buying all the new ships the Navy wants, the cost of operating and maintaining a 355-ship fleet over 30 years would be much greater than either the cost of purchasing the new ships or the recent budgets for operating today's fleet.⁷

Ship Purchases and Inventories Under the 2019 Plan

The Navy's 2019 shipbuilding plan, which the Department of Defense submitted to the Congress on February 9, 2018, reflects the inventory goal of 355 battle force ships that the service set forth in its 2016 force structure assessment. (For a comparison of the goals established in the five most recent force

7. See Congressional Budget Office, *Costs of Building a 355-Ship Navy* (April 2017), pp. 5–7, www.cbo.gov/publication/52632, and *The U.S. Military's Force Structure: A Primer* (July 2016), www.cbo.gov/publication/51535.

Box 1.

Major Types of Ships in the Navy's Fleet

Nimitz Class Aircraft Carrier



The Navy's 11 **aircraft carriers** are the heart of the battle force. Each carries an air wing of about 60 aircraft, which can attack hundreds of targets per day (based on 12 hours of flight operations) for up to a month before needing to rest. Carriers are the largest ships in the fleet, with a displacement of about 100,000 tons. (A ship's displacement is the weight of water that it displaces when floating or, in the case of a submarine, when submerged.) Ten of the current carriers belong to the Nimitz class. The Navy commissioned the first of a new class, the *Gerald R. Ford*, in 2017.

Ohio Class Ballistic Missile Submarine



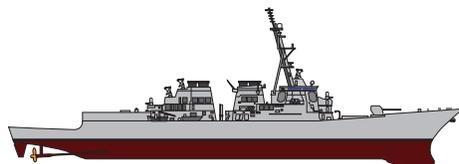
Strategic ballistic missile submarines are one component of the U.S. nuclear triad. Each submarine carries up to 20 Trident missiles armed with 1 to 8 nuclear warheads apiece. (Originally they were built with 24 missile tubes, but arms control treaties now limit them to 20 operational tubes.) The Navy has 14 Ohio class ballistic missile submarines, each of which displaces about 19,000 tons when submerged. The service has 4 other submarines of that class that it converted to a conventional guided missile (SSGN) configuration. Those SSGNs carry up to 154 Tomahawk missiles as well as special operations forces.

Virginia Class Attack Submarine



Attack submarines are the Navy's premier undersea warfare and antisubmarine weapons. Since the end of the Cold War, however, they have mainly been used for covert intelligence gathering. They can also launch Tomahawk missiles at inland targets in the early stages of a conflict. Of the Navy's 50 attack submarines, 32 belong to the Los Angeles class. Displacing 7,000 tons when submerged, they are less than half the size of ballistic missile submarines. Virginia class attack submarines are a little larger, at 7,800 tons.

Arleigh Burke Class Destroyer



Large surface combatants, which include cruisers and destroyers, are the workhorses of the fleet. They provide ballistic missile defense for the fleet and for overseas regions. They defend aircraft carriers and amphibious warfare ships against other surface ships, aircraft, and submarines, and they perform such day-to-day missions as patrolling sea lanes, providing an overseas presence, and conducting exercises with allies. They can also launch Tomahawk missiles to strike land targets. Most of the Navy's surface combatants displace about 9,000 to 10,000 tons.

Box 1.

Continued

Major Types of Ships in the Navy's Fleet

Freedom Class Littoral Combat Ship



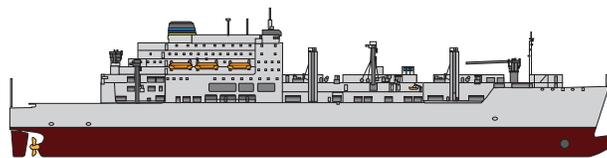
Small surface combatants include littoral combat ships (LCSs) and frigates. LCSs, which are built in two variants, are intended to counter mines, small boats, and diesel-electric submarines in the world's coastal regions. The Navy's new frigates, which it will begin building in 2020, are expected to be multimission ships, capable of performing many of the missions of the LCS but also carrying robust antiship capabilities as well as being able to defend against threats in the immediate area. More routinely, LCSs and frigates—like their counterparts, the large surface combatants—patrol sea lanes, provide an overseas presence, and conduct exercises with allies. They range in size from 3,000 to 4,000 tons. The Navy currently has no frigate because it retired all of its Oliver Hazard Perry frigates as of 2015.

San Antonio Class Amphibious Transport Dock



The Navy has five classes of **amphibious warfare ships**. The two classes referred to as amphibious assault ships (also known as large-deck amphibious ships or helicopter carriers) are the second-largest types of ships in the fleet, displacing between 40,000 and 45,000 tons. With capacity for about half the troops and equipment of a Marine expeditionary unit, the amphibious assault ship is the centerpiece of the amphibious ready group. In addition to troops, each ship can carry as many as 30 helicopters and 6 fixed-wing Harrier jump jets or short takeoff and landing versions of the Joint Strike Fighters (F-35Bs), or up to 20 of those fixed-wing aircraft. The other three classes are divided into two types: amphibious transport docks and dock landing ships. Two of those ships together provide the remaining transport capacity for a Marine expeditionary unit in an amphibious ready group. They range in size from 16,000 to 25,000 tons.

Lewis and Clark Class Dry Cargo/Ammunition Ship



The many **combat logistics and support ships** in the Navy's fleet provide the means to resupply, repair, salvage, or tow combat ships. The most prominent of those vessels are fast combat support ships, which resupply carrier strike groups with fuel, dry cargo (such as food), and ammunition. Logistics and support ships can be as small as 2,000 tons for an oceangoing tug or as large as 50,000 tons for a fully loaded fast combat support ship.

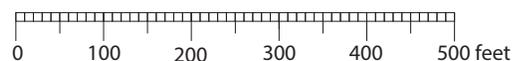


Figure 1.

Average Annual Costs of New-Ship Construction Under the Navy's 2019 Plan

Billions of 2018 Dollars



Source: Congressional Budget Office, using data from the Department of the Navy.

Costs of new-ship construction exclude funds for refueling nuclear-powered aircraft carriers and for ship conversions, construction of ships that are not part of the Navy's battle force (such as oceanographic survey ships) and training ships, outfitting and postdelivery activities (including the purchase of smaller tools and pieces of equipment that are needed to operate a ship but that are not necessarily provided by the manufacturing shipyard as part of ship construction), and smaller items. The costs of the mission packages for littoral combat ships, which are not funded in the Navy's shipbuilding accounts, also are excluded.

structure assessments, see Table 3).⁸ The Navy intends to buy 10 ships in 2019 and 44 ships from 2020 through 2023—the period covered by DoD's 2019 Future Years Defense Program (see Figure 3 on page 9 and Figure 4 on page 10). From 2024 through 2048, the Navy would buy an additional 247 ships, for a total of 301 ships over 30 years, or an average of about 10 ships per year. The pace of shipbuilding would be faster, on average, in the first 15 years of the plan than later on, reflecting the service's desire to increase the size of the fleet as quickly as practical. The Navy plans to purchase ships at an

average annual rate of 11.2 ships from 2019 to 2033 and 8.8 ships from 2034 to 2048.⁹

The Navy projects that it cannot reach its goal of 355 ships with only the new-ship construction program outlined in the 2019 plan; it also wants to extend the service life of its destroyers and a few attack submarines. The service projects that it will have 299 ships in the fleet at the end of 2019. Without those service life extensions, under its current ship-counting rules, the Navy's battle force would fluctuate between 310 and

8. Department of the Navy, *Executive Summary, 2016 Navy Force Structure Assessment (FSA)* (December 2016), <http://tinyurl.com/zgdk5o7>. For a more extensive discussion of the history of the Navy's force structure goals, see Ronald O'Rourke, *Navy Force Structure and Shipbuilding Plans: Background and Issues for Congress*, Report for Congress RL32665 (Congressional Research Service, updated July 31, 2018), <https://crsreports.congress.gov/product/pdf/RL/RL32665> (3.2 MB).

9. Although most new ships are built to replace older ships as they retire (such as the new ballistic missile submarines that are proposed for the 2020s and 2030s), the Navy sometimes builds ships to fulfill a new mission or to satisfy a specific need. For example, several years ago, the Navy canceled the DDG-1000 destroyer program and restarted its DDG-51 destroyer line after determining the need for different types of ships. The new Montford Point class of expeditionary transfer docks represents a new type of ship that will meet a new need for the Navy.

320 ships through the early 2030s. It would reach a high of 342 ships in 2039, before falling back to 335 by 2048 (see the bottom panel of Figure 3). The service life extensions of destroyers and attack submarines, along with the new-ship construction in the 2019 plan, would result in the fleet growing to 355 ships by 2034 and staying at or above that level through 2047, before dropping to 350 ships in 2048.

This report assesses the costs of implementing the 2019 plan, the plan's effects on the force structure, and the extent to which it would satisfy the Navy's specific goals for major components of the U.S. fleet. This report also shows the effect on those goals of the Navy's subsequent decision to extend the service life of its destroyers and some attack submarines. CBO did not evaluate the validity of the Navy's goals or the fleet's ability to fulfill its missions in the national military strategy.

Combat Ships

Over the next 30 years, the Navy envisions buying 245 combat ships, including aircraft carriers, submarines, large and small surface combatants, and amphibious warfare ships. Although that total represents 36 more ships than the Navy called for in its 2017 plan, those purchases would leave the Navy short of its inventory objectives for aircraft carriers, ballistic missile submarines, attack submarines, large surface combatants, small surface combatants, and amphibious ships for significant segments of the 2019–2048 period (see Figure 5 on page 12). Extending the service life of all destroyers to 45 years would erase the shortfall in large surface combatants for almost the entire period.

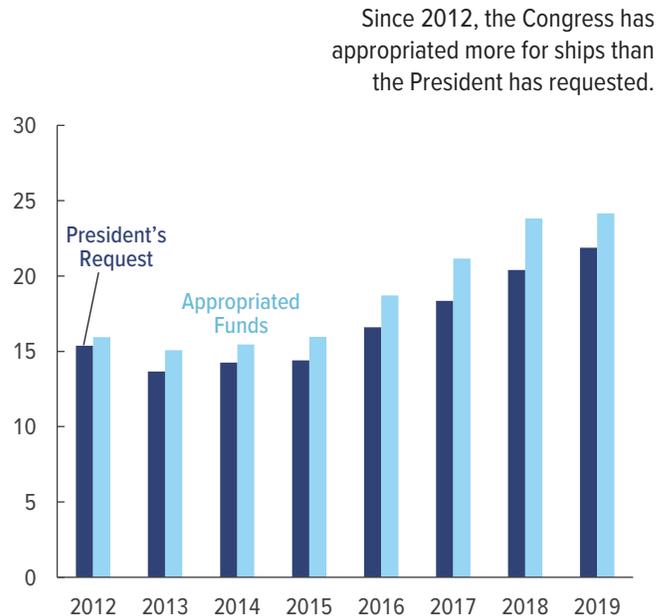
Aircraft Carriers. Under its 2019 shipbuilding plan, the Navy would purchase 7 aircraft carriers between 2019 and 2048 at a rate of 1 every 5 years through 2028 and 1 every 4 years thereafter. That plan would allow the Navy to maintain a force of 11 aircraft carriers through 2039. Given the carriers' 50-year expected service life, however, the force would fall to 10 carriers in 2040 and to 9 carriers by 2048. (To reach and sustain a force of 12, its stated goal, the Navy would need to purchase 1 ship every 3 years for the entire 30-year period.)¹⁰

10. See Congressional Budget Office, *Costs of Building a 355-Ship Navy* (April 2017), pp. 10–11, www.cbo.gov/publication/52632.

Figure 2.

Requested and Appropriated Shipbuilding Budgets, 2012 to 2019

Billions of Dollars



Source: Congressional Budget Office, using various volumes of the Department of the Navy's *Highlights of the Department of the Navy Budget*.

Ballistic Missile Submarines. The 2019 shipbuilding plan calls for buying the first Columbia class ballistic missile submarine (SSBN) in 2021 to begin replacing the current Ohio class SSBNs and for purchasing 11 more by 2036. The Navy estimates that the lead submarine will take at least 7 years to build, so the first Columbia class SSBN would be commissioned into the fleet in 2028. (It would, however, take 2 to 3 additional years before it went on its first deterrent patrol.) Subsequent submarines in the class would take about 7 years to build and test. Because the Ohio class submarines will be retired at the end of 42 to 44 years of service, the Navy's inventory of SSBNs would fall at least 1 ship short of its goal of 12 SSBNs between 2030 and 2041. From 2037 to 2040, the Navy would have only 10 SSBNs.

Attack Submarines. Under the 2019 plan, the Navy would purchase 60 attack submarines (SSNs) through 2048, 16 more than under the 2017 plan. They would be built at a rate of 2 per year for 30 years, which would not allow the Navy to meet its inventory goal of 66 until

Table 3.

The Navy's Inventory Goals, as Stated in Its Force Structure Assessments

	2005 Force Structure Assessment	2010 Force Structure Assessment	2012 Force Structure Assessment	2014 Update of the 2012 Force Structure Assessment	2016 Force Structure Assessment
Aircraft Carriers	11	11	11	11	12
Submarines					
Ballistic missile	14	12	12	12	12
Attack	48	48	48	48	66
Guided missile	4	4	0	0	0
Large Surface Combatants	88	94	88	88	104
Small Surface Combatants and Mine Countermeasures Ships ^a	55	55	52	52	52
Amphibious Warfare Ships	31	33	33	34	38
Maritime Prepositioning Force (Future) Ships	12	0	0	0	0
Combat Logistics Ships	30	30	29	29	32
Support Ships					
Expeditionary fast transports (Formerly joint high-speed vessels)	3	10	10	10	10
Other ^b	<u>17</u>	<u>16</u>	<u>23</u>	<u>24</u>	<u>29</u>
Total	313	313	306	308	355

Source: Congressional Budget Office, using data from the Department of the Navy.

a. Small surface combatants include frigates and littoral combat ships.

b. Includes command ships, salvage ships, ocean tugs, ocean surveillance ships, and tenders.

2048. Unless the Navy extends the service life of some of its existing attack submarines, the number of attack submarines would decline from 52 today to a low of 42 in 2028.¹¹ The force would then gradually grow to 66 over the next 20 years.

If the Navy carries through with its plan to extend the service life of 6 additional Los Angeles class submarines (one refueling is already part of the 2019 plan), then the force would only fall to 45 by 2026.¹² Although refueling 6 more existing submarines would boost the force over the following 20 years, those service life extensions

would not allow the Navy to meet its goal of 66 SSNs sooner than 2048, because even with a longer service life they would all retire by 2040.

Large Surface Combatants. The 2019 shipbuilding plan calls for buying 76 destroyers and new large surface combatants, 10 more than the 2017 plan. Of that number, 29 would be based on the existing Arleigh Burke class destroyer (DDG-51) design and 47 would be a new design. Those planned purchases, along with the Navy's plan to modernize its existing cruiser force, would not be enough for the service to meet or exceed its inventory goal of 104 large surface combatants (LSCs) for almost the entire 30-year period.

However, the Navy's plan to extend the service life of all existing Arleigh Burke class destroyers to 45 years would allow the Navy to meet its goal of 104 large surface combatants in 2029 and stay above that number through 2048 (see the fourth panel of Figure 5 on page 12). The 2019 plan also differs from the 2017 plan in that it calls for extending the service life of 7 Ticonderoga class

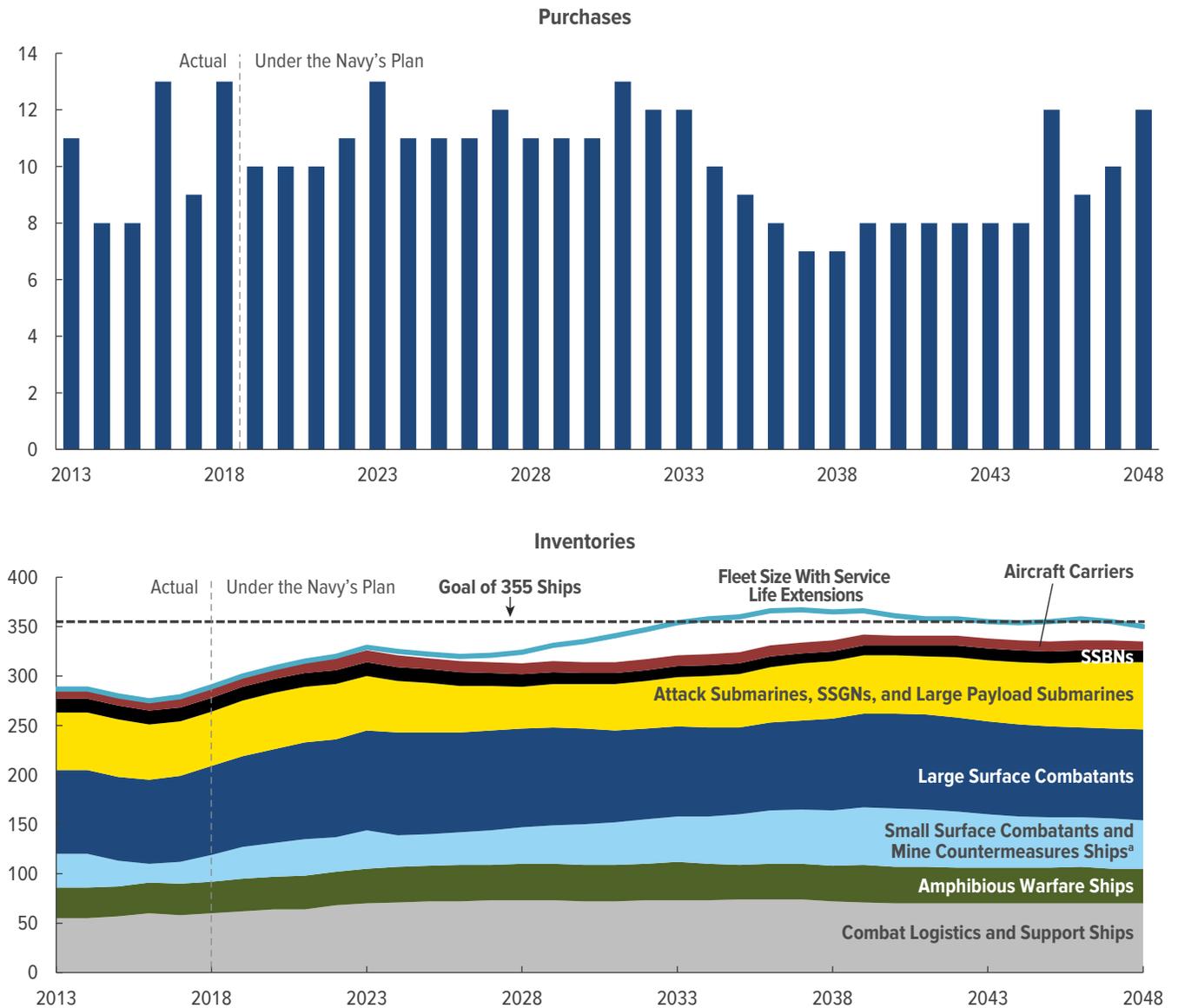
11. The decline is the result of the retirement, beginning in 2014, of Los Angeles class attack submarines (SSN-688s). Those ships, which were generally built at a rate of 3 or 4 per year during the 1970s and 1980s, are reaching the end of their 33-year service life. Under the 2019 plan, the Navy would replace them with Virginia class attack submarines (SSN-774s) and their successors at a rate of 2 per year.

12. Refueling an attack submarine (or an aircraft carrier) involves replacing the spent nuclear fuel rods in the reactor cores of nuclear-powered ships with new ones.

Figure 3.

Annual Ship Purchases and Inventories Under the Navy's 2019 Plan

Number of Ships



Source: Congressional Budget Office, using data from the Department of the Navy.

SSBNs = ballistic missile submarines; SSGNs = guided missile submarines.

a. Includes littoral combat ships, Oliver Hazard Perry FFG-7 frigates, new frigates, new small surface combatants, and Avenger class mine countermeasures ships.

cruisers by several years but shortening the service life of the remaining cruisers.

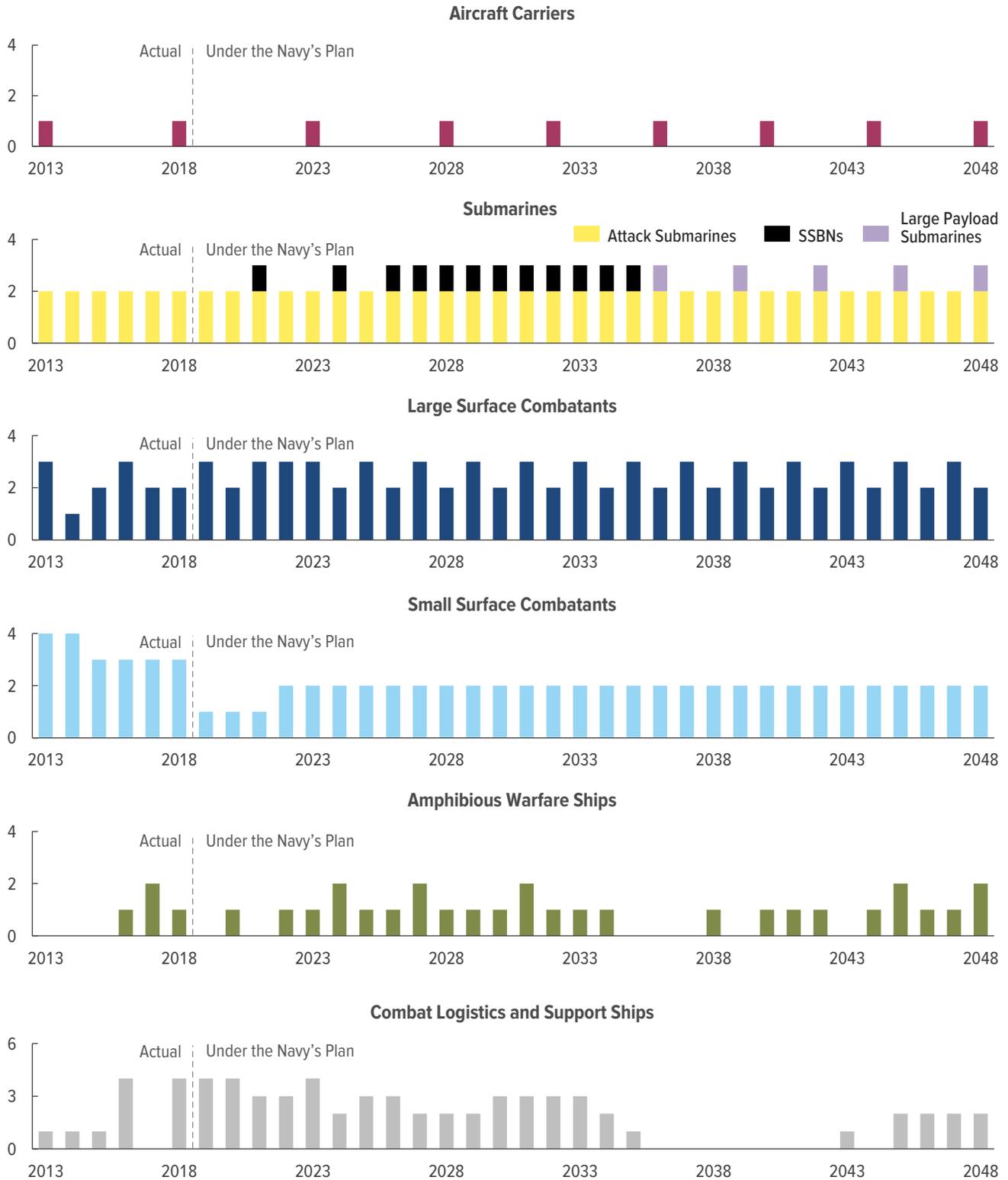
Small Surface Combatants. For small surface combatants (SSCs), the Navy has 31 littoral combat ships in the fleet or under construction and 11 mine countermeasures ships. Under the 2019 plan, the service would purchase

20 guided missile frigates, designated FFG(X), and 36 future small surface combatants that would probably resemble a guided missile frigate. The construction plan would allow the Navy to reach its goal of 52 small surface combatants by 2034 and remain at or above that number through 2045, before declining slightly to between 49 and 51 ships for the remaining few years of

Figure 4.

Annual Ship Purchases Under the Navy's 2019 Plan, by Category

Number of Ships



Source: Congressional Budget Office, using data from the Department of the Navy.

SSBNs = ballistic missile submarines.

the plan. (The plan also calls for extending the service life of 4 mine countermeasures ships by several years in the 2020s, but all of those ships would be retired by 2024.)

Amphibious Warfare Ships. The Navy's 2019 plan calls for buying 28 amphibious warfare ships through 2048—5 more than under the 2017 plan—and increasing the amphibious force from the current 32 ships to a high of 39 ships by 2033. The force would then fluctuate between 35 and 38 ships for the remainder of the period. Overall, the Navy would hit its target of 38 amphibious warfare ships for only two years under the 2019 plan, although it would never be more than 3 ships short of its goal after 2022.

Combat Logistics and Support Ships

Under the 2019 plan, the Navy would buy 56 combat logistics and support ships in the next three decades—11 more than under the 2017 plan. Combat logistics ships include T-AKE dry cargo ships, TAO oilers, and AOE fast combat support ships; they operate with or directly resupply combat ships that are under way. The plan calls for purchasing 18 new oilers (which provide fuel and other supplies to ships at sea) at a rate of 1 or 2 per year from 2019 through 2033 and 9 replacements for T-AKE dry cargo and ammunition ships from 2043 to 2048. Under the plan, the Navy would also purchase 27 other support ships: 10 expeditionary fast transports (formerly called joint high-speed vessels), 6 salvage/fleet tug ships, 7 surveillance ships, 2 expeditionary sea bases, and 2 tenders. In addition, the Navy would buy 2 command ships to replace its existing vessels, a program that has not been included in the last several shipbuilding plans.

Shipbuilding Costs Under the 2019 Plan

According to the Navy's estimates, its planned purchases of new ships would cost (that is, require appropriations of) an average of \$21.0 billion per year in 2018 dollars through 2048 (see Table 4)—19 percent more than the \$17.7 billion average funding per year that the service estimated it would need to carry out its 2017 plan (see Figure 6 on page 14). In making its estimates, the Navy divided the time frame of the 2018 plan into three periods: the near term (2019 to 2023), the midterm (2024 to 2028), and the far term (2029 to 2048).

CBO also estimated the costs of the Navy's 2019 plan, using its own cost models and assumptions to price the ships. On average, CBO's estimates of the new-ship construction costs are \$5.7 billion (or 26 percent) higher per year than the Navy's for the 30-year period. The differences between CBO's and the Navy's estimates increase over time: They are smallest for the near term and largest for the far term. Other activities that the Navy would need to fund from its budget account for ship construction add \$2.2 billion more per year to the Navy's and CBO's estimates, bringing the total estimated annual cost for ship construction to \$23.2 billion (on the basis of the Navy's estimate of new-ship construction costs) or \$28.9 billion (CBO's estimate).

The Navy's Estimates

The Navy's 2019 report is a relatively brief document that discusses its future shipbuilding procurements, retirements, and inventory projections. It outlines the Navy's planned shipbuilding purchases over a 30-year period with average funding roughly equivalent to the average funding anticipated for 2022 and 2023. The report also emphasizes the importance of steady work for the shipbuilding industry to prevent boom and bust cycles, which could jeopardize the financial health of some shipyards and secondary suppliers as well as create uncertainty about the cost of future shipbuilding plans.¹³

New-Ship Construction Costs. According to the Navy's estimates for its 2019 plan, new-ship construction would cost an average of \$19.7 billion per year over the near term. That amount excludes about \$460 million needed to cover cost overruns related to the construction of ships funded before 2019; that sum would be spent from 2019 through 2022.

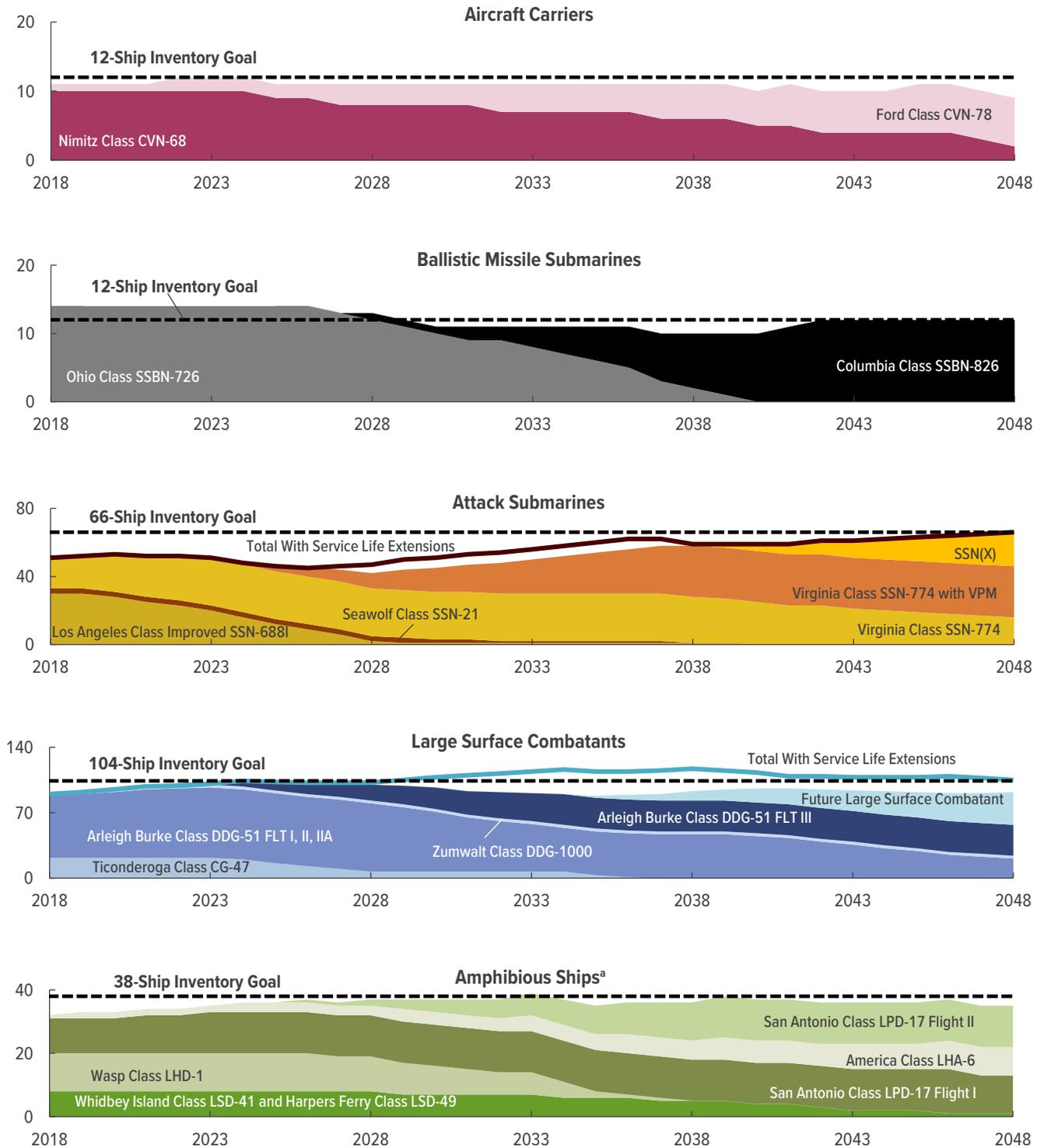
The Navy estimates that the average annual cost for new-ship construction would rise from \$19.7 billion in the near term to \$22.7 billion in the midterm (see Figure 7 on page 15). The costs for the far term, which includes

13. In an appendix, the Navy offers a framework whereby, if more budgetary resources were made available, additional ships could be added to the shipbuilding plan to achieve a 355-ship fleet sooner without disrupting the shipbuilding industry. Detailed cost projections are provided in Appendix 8 of the report, a limited-distribution document that the Navy made available to CBO.

Figure 5.

Annual Inventories Under the Navy's 2019 Plan Versus Goals for Selected Categories of Ships

Number of Ships



Source: Congressional Budget Office.

CG = guided missile cruiser; CVN = nuclear-powered aircraft carrier; DDG and DDG(X) = guided missile destroyer; LHA and LHD = amphibious assault ship; LPD = amphibious transport dock; LSD = dock landing ship; SSBN = ballistic missile submarine; SSN and SSN(X) = attack submarine; VPM = Virginia payload module.

a. Does not include the LPD-17 added by the Congress in the 2018 appropriation act.

Table 4.

Average Annual Shipbuilding Costs Under the Navy's 2019 Plan

	Near Term (2019–2023)	Midterm (2024–2028)	Far Term (2029–2048)	All Three Decades (2019–2048)
Navy's Estimates (Billions of 2018 dollars)				
New-Ship Construction	19.7	22.7	21.1	21.0
New-Ship Construction and Refueling of Nuclear-Powered Aircraft Carriers ^a	21.0	25.0	22.0	22.2
New-Ship Construction, Refueling of Nuclear-Powered Aircraft Carriers, and Other Items ^b	22.2	26.3	22.8	23.2
CBO's Estimates (Billions of 2018 dollars)				
New-Ship Construction	20.0	25.7	28.6	26.7
New-Ship Construction and Refueling of Nuclear-Powered Aircraft Carriers	21.3	28.0	29.5	27.9
New-Ship Construction, Refueling of Nuclear-Powered Aircraft Carriers, and Other Items	22.5	29.3	30.4	28.9
Percentage Difference Between the Navy's and CBO's Estimates				
New-Ship Construction	2	13	36	27
New-Ship Construction and Refueling of Nuclear-Powered Aircraft Carriers	1	12	34	26
New-Ship Construction, Refueling of Nuclear-Powered Aircraft Carriers, and Other Items	1	11	33	24

Source: Congressional Budget Office, using data from the Department of the Navy.

Costs are the appropriation of budget authority necessary to implement the Navy's plan.

Costs for other items include funds for ship conversions and for ships that are not part of the Navy's battle force (such as oceanographic survey ships) and training ships, outfitting and postdelivery activities (including the purchase of smaller tools and pieces of equipment that are needed to operate a ship but that are not necessarily provided by the manufacturing shipyard as part of ship construction), and smaller items. Actual costs for the Navy's shipbuilding accounts over the past 30 years averaged about \$16 billion per year (in 2018 dollars) for all items.

- a. These figures include the Navy's estimates for new-ship construction and CBO's estimates for the refueling of nuclear-powered aircraft carriers.
- b. These figures include the Navy's estimates both for new-ship construction and for the cost to complete ships purchased in prior years and CBO's estimates for the refueling of nuclear-powered aircraft carriers and for other items.

7 years in which the Navy plans to purchase Columbia class ballistic missile submarines and 13 more years at the end of the planning period, would average \$21.1 billion per year—55 percent more than the \$13.6 billion the Navy has received, on average, over the past 30 years.

Total Shipbuilding Costs. As in previous shipbuilding plans, the Navy's 2019 estimates exclude the following costs, which it would need to cover with funds from its budget account for ship construction:

- The cost of refueling nuclear-powered aircraft carriers midway through their 50-year service life, which CBO estimates would add \$1.2 billion per year to the Navy's estimate of the cost of

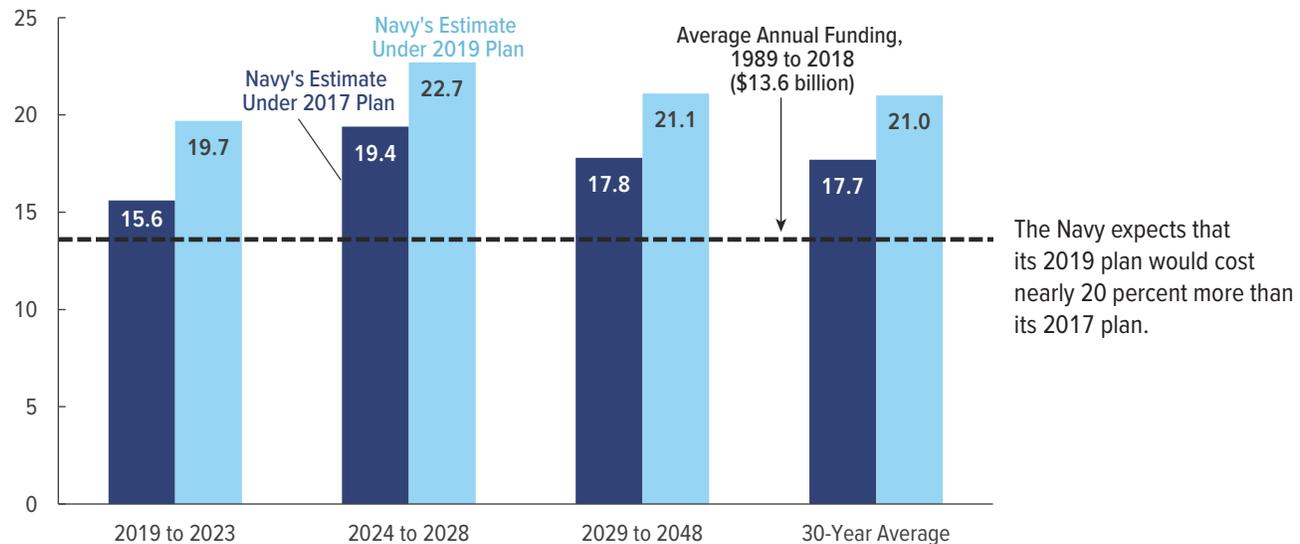
implementing the 2019 plan, bringing the average cost to \$22.2 billion a year through 2048;¹⁴ and

14. In 2010, the Navy transferred funding for refueling nuclear-powered submarines from its Shipbuilding and Conversion account to three other accounts (Other Procurement, Operation and Maintenance, and Weapons Procurement) that are not used to purchase ships. Therefore, CBO did not include the refueling costs for submarines in its estimates of future shipbuilding costs, nor do the estimates include the costs for the destroyer service life extensions. Spending in those accounts would be greater under the Navy's 2019 plan than under its 2017 plan to fund the refueling and life extension of 6 additional Los Angeles class submarines that the Navy expects to undertake. For further discussion of those costs, see Congressional Budget Office, *Comparing a 355-Ship Fleet With Smaller Naval Forces* (March 2018), www.cbo.gov/publication/53637.

Figure 6.

The Navy's Estimates of the Average Annual Costs of New-Ship Construction Under Its 2017 and 2019 Plans

Billions of 2018 Dollars



Source: Congressional Budget Office, using data from the Department of the Navy.

Costs for new-ship construction exclude funds for refueling nuclear-powered aircraft carriers and for ship conversions, construction of ships that are not part of the Navy's battle force (such as oceanographic survey ships) and training ships, outfitting and postdelivery activities (including the purchase of smaller tools and pieces of equipment that are needed to operate a ship but that are not necessarily provided by the manufacturing shipyard as part of ship construction), and smaller items. The costs of the mission packages for littoral combat ships, which are not funded in the Navy's shipbuilding accounts, also are excluded.

- The costs of ship conversions, construction of ships that are not part of the Navy's battle force (oceanographic survey ships, for instance), moored training ships, outfitting and postdelivery activities (including the purchase of many smaller tools and pieces of equipment that are needed to operate a ship but that are not necessarily provided by the shipyard when the ship is built), and smaller items. Together, those items would boost the Navy's estimate by \$0.9 billion per year through 2048, CBO projects.

Adding those costs, plus the \$460 million that will be spent from 2019 through 2022 to cover cost overruns, to the estimated cost of new-ship construction would boost the Navy's estimate for the 30-year cost of the 2019 shipbuilding plan to an average of \$23.2 billion per year—\$2.2 billion more than its estimate for new-ship construction alone. That amount is 47 percent greater than the average funding of \$15.8 billion per year that

the Navy has received for shipbuilding over the past three decades.

CBO's Estimates

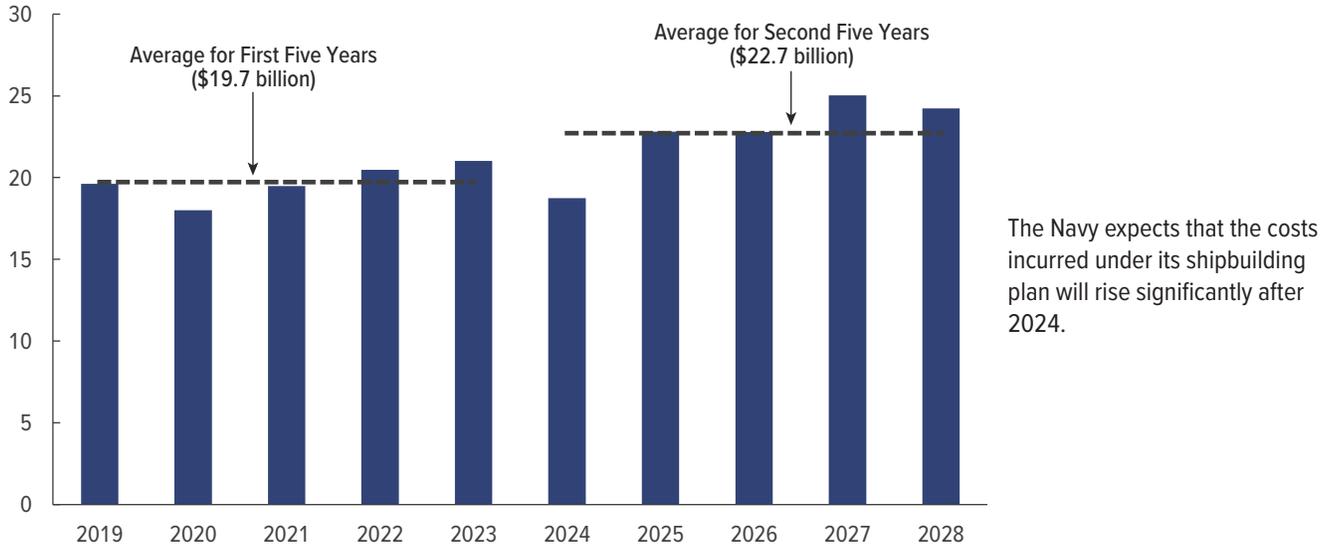
According to CBO's estimate, the full cost of the 2019 shipbuilding plan (including construction, refueling of nuclear-powered aircraft carriers, and other items) would average \$28.9 billion per year in 2018 dollars over the 2019–2048 period (see Table 4). That amount is 80 percent greater than the average annual funding the Navy has received over the past three decades. The estimated costs vary from year to year but generally trend upward for the first half of the plan (see Figure 8). CBO makes the following estimates for the 30-year period as a whole:

- New-ship construction would cost an average of \$26.7 billion per year, 26 percent more than the Navy's estimate of \$21.0 billion;

Figure 7.

The Navy's Estimates of the Costs of New-Ship Construction, 2019 to 2028

Billions of 2018 Dollars



Source: Congressional Budget Office, using data from the Department of the Navy.

Costs for new-ship construction exclude funds for refueling nuclear-powered aircraft carriers and for ship conversions, construction of ships that are not part of the Navy's battle force (such as oceanographic survey ships) and training ships, outfitting and postdelivery activities (including the purchase of smaller tools and pieces of equipment that are needed to operate a ship but that are not necessarily provided by the manufacturing shipyard as part of ship construction), and smaller items. The costs of the mission packages for littoral combat ships, which are not funded in the Navy's shipbuilding accounts, also are excluded.

- New-ship construction plus refueling of nuclear-powered aircraft carriers would cost an average of \$27.9 billion per year, 25 percent more than the \$22.2 billion estimate that is based on the Navy's projection of new-ship construction costs plus CBO's estimate of refueling nuclear-powered aircraft carriers; and
- All other items would add annual costs of about \$900 million, raising CBO's estimate to an average of \$28.9 billion per year through 2048, 24 percent more than the \$23.2 billion estimate that is based on the Navy's projection of new-ship construction costs and CBO's estimate of all other costs.

CBO's estimates of the full cost of the plan are only 1 percent higher than the Navy's for the near term, which coincides with DoD's Future Years Defense Program, but they are 32 percent higher for the far term. The two sets of estimates are similar for the near term because most of the ships that the Navy plans to buy are

already under construction and their costs are reasonably well known. But CBO's and the Navy's different assumptions about the size and capabilities of future ships led to different cost estimates for the midterm and far term. In particular, two large future programs—the new attack submarine and the large surface combatant to be built in the 2030s and 2040s—account for much of the difference between the Navy's and CBO's estimates. (The details of those differences are discussed later in this report.)

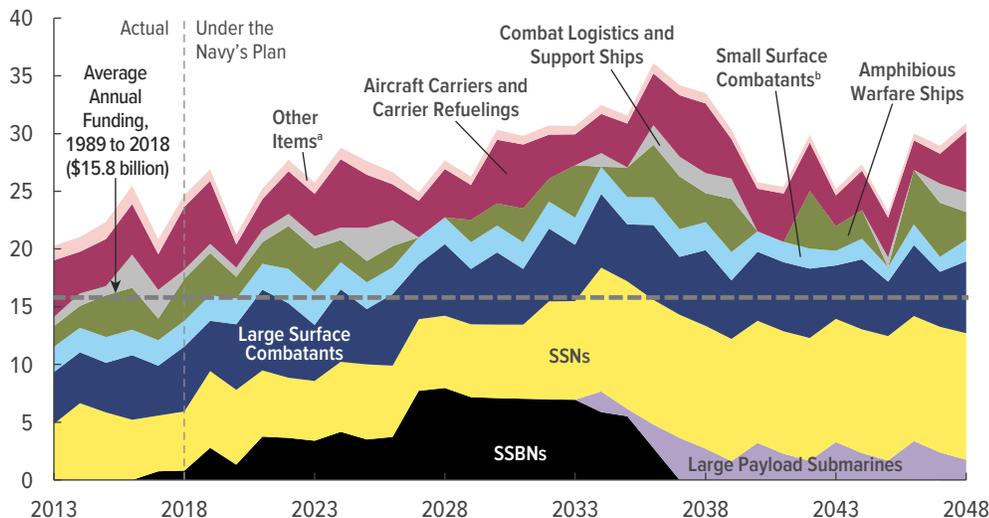
Operation and Support Costs

In addition to the costs of buying 301 new ships, a larger fleet would cost more to operate: More ships would require more sailors; recruiting and training those sailors would require more civilian and military positions ashore; additional ships would lead to larger maintenance budgets; and those extra ships and crews would consume more fuel and supplies, during both training exercises and deployments. For this analysis, CBO did not estimate operation and support costs for a

Figure 8.

CBO's Estimates of Annual Shipbuilding Costs Under the Navy's 2019 Plan

Billions of 2018 Dollars



Over the next three decades, CBO estimates, the new SSBN and new attack submarine programs would push the Navy's annual shipbuilding costs well above the historical average.

Source: Congressional Budget Office, using data from the Department of the Navy.

SSBNs = ballistic missile submarines; SSNs = attack submarines.

a. Includes ship conversions, ships that are not part of the Navy's battle force (such as oceanographic survey ships) and training ships, outfitting and postdelivery activities (including the purchase of smaller tools and pieces of equipment that are needed to operate a ship but that are not necessarily provided by the manufacturing shipyard as part of ship construction), and smaller items.

b. The costs of the mission packages for littoral combat ships, which are not funded in the Navy's shipbuilding accounts, are not included.

larger fleet, nor did CBO include the costs of extending the service life of all the Navy's destroyers to 45 years or refueling 7 Los Angeles class submarines. In prior work, however, CBO estimated operation and support costs as well as the costs of service life extensions.¹⁵ Operation and support costs for a fleet that reached 355 ships in the mid-2030s—which is essentially the Navy's plan with the service life extensions—would average about \$80 billion a year and total about \$2.4 trillion over 30 years. That annual amount represents about 40 percent more than what it costs the Navy to operate its current fleet today. The service life extensions represent a relatively small amount of money: about 2 percent of the overall cost of building and operating a 355-ship fleet.

15. See Congressional Budget Office, *Comparing a 355-Ship Fleet With Smaller Naval Forces* (March 2018), pp. 1–3, 7–10, www.cbo.gov/publication/53637, and *Costs of Building a 355-Ship Navy* (April 2017), pp. 6–8, www.cbo.gov/publication/52632.

Plans for Specific Ship Programs

To project the costs of implementing the Navy's 2019 shipbuilding plan, CBO estimated the cost of each of the 301 ships that the Navy intends to purchase between 2019 and 2048. For ships under construction, the estimates were based in part on the Navy's data for actual costs. For ships yet to be built, CBO based the estimates primarily on information about the cost-to-weight ratio of similar ships acquired in the past.

Specifically, CBO used the cost per thousand tons of lightship displacement, which is the weight of the water that the ship displaces without its crew, stores, ammunition, fuel, or other liquids. CBO then adjusted its estimates to incorporate the effects of rate (the reduction in average overhead costs that occurs as a shipyard builds multiple ships of the same type simultaneously) and learning (the efficiencies that shipyards gain as they produce additional units of a given type of ship). The effects of rate and learning were

applied to the estimated cost of the first ship of a class (the lead ship) to determine the estimated costs for all subsequent ships of that class. Thus, CBO's estimate of the cost of the lead ship of a class drove its estimate of the costs of subsequent ships of that class. In a report published in April 2018, *How CBO Estimates the Cost of New Ships*, CBO explains how it combines the different factors in its cost model. In addition, the report provides a detailed example of how CBO arrived at the cost of one particular ship.¹⁶

For ships for which the Navy has not yet developed designs, CBO had to make assumptions about their size and capabilities. All cost estimates for specific ships exclude outfitting and postdelivery costs, which typically add at least 3 percent to a ship's cost; those costs are included as "other items" in the totals. CBO also incorporated into its estimates (which are in 2018 dollars) a projection that labor and materials costs would probably continue to grow 1.2 percent faster in the naval shipbuilding industry than in the economy as a whole, as they have for the past several decades.

Aircraft Carriers

According to the 2019 shipbuilding plan, the Navy's ultimate goal is to have 12 aircraft carriers, and it intends to buy 7 CVN-78 Gerald R. Ford class aircraft carriers over the 2019–2048 period in pursuit of that objective. To project those costs, CBO considered the costs of 3 carriers that have already received some or all of their funding.

The Navy's current estimate of the total cost of the *Gerald R. Ford*, the lead ship of the CVN-78 class, is \$13.0 billion in nominal dollars appropriated over the period from 2001 to 2018, an amount that is equal to the cost cap set in law. CBO used the Navy's inflation index for naval shipbuilding to convert that figure to \$15.5 billion in 2018 dollars, or 23 percent more than the corresponding estimate when the ship was first authorized in 2008.¹⁷ Neither the Navy's nor CBO's estimate includes the \$5 billion in research and development costs that apply to the entire class.

Because construction of the lead ship is finished, CBO used the Navy's estimate for that ship to estimate the cost of successive ships in the class. But not all of the cost risk has been eliminated; in particular, the ship's power systems and advanced arresting gear (the system used to recover fixed-wing aircraft landing on the ship) are not yet working properly. It is not clear how much those problems will cost to fix, but current Navy estimates suggest that it will be several tens of millions of dollars or more. CBO does not have enough information to estimate those final repair costs.¹⁸

The next carrier after the CVN-78 will be the CVN-79, the *John F. Kennedy*. Funding for that ship began in 2007, the Congress officially authorized its construction in 2013, and the planned appropriations for it were completed in 2018. The shipbuilder expects to complete construction of the CVN-79 in 2024 and deploy it for the first time in 2026. The Navy estimates that the ship will cost \$11.3 billion in nominal dollars (or \$11.6 billion in 2018 dollars). The Navy's selected acquisition report on the CVN-79 states that "the Navy and shipbuilder have made fundamental changes in the manner in which the CVN 79 will be built to incorporate lessons learned from CVN 78 and eliminate the key contributors to cost performance challenges realized in the construction of CVN 78."¹⁹ Nevertheless, the Navy informed CBO that there is a greater than 60 percent chance that the ship's final cost will be more than the current estimate. Although CBO expects the Navy to achieve a considerable cost reduction in the CVN-79 compared with the CVN-78, as is typical with the second ship of a class, CBO's estimate is higher than the Navy's. Specifically, CBO estimates that the ship will cost \$11.7 billion in nominal dollars (or \$12.0 billion in 2018 dollars), about 4 percent more than the Navy's estimate.

In 2018, the Congress authorized the third carrier of the class, the *Enterprise* (CVN-80). Appropriations for that ship began in 2016 and are expected to be complete by 2023. The Navy estimates that the ship will cost

16. See Congressional Budget Office, *How CBO Estimates the Costs of New Ships* (April 2018), www.cbo.gov/publication/53785.

17. For more on the calculation of the cost cap, see Congressional Budget Office, *Inflation in the Costs of Building Aircraft Carriers* (April 2016), www.cbo.gov/publication/51469.

18. See, for example, Anthony Capaccio, "Navy's \$12.9 Billion Carrier Isn't Ready for Warfare, Memo Says," *Bloomberg* (July 20, 2016), <http://tinyurl.com/z7q3xxh>.

19. Defense Acquisition Management Information Retrieval, *Selected Acquisition Report (SAR): CVN 78 Gerald R. Ford Class Nuclear Aircraft Carrier, as of FY 2016 President's Budget* (Department of the Navy, December 2014), p. 29.

\$12.6 billion in nominal dollars (or \$11.5 billion in 2018 dollars). However, as with CVN-79, the Navy told CBO that there is a greater than 60 percent chance that the ship's final cost will be more than the current estimate. CBO estimates that the ship will cost \$13.0 billion in nominal dollars (or \$11.8 billion in 2018 dollars), about 3 percent more than the Navy's estimate.

The Navy estimates an average cost of \$12.4 billion (in 2018 dollars) for the 7 carriers (CVN-81 through CVN-87) in the 2019 shipbuilding plan. CBO's estimate is \$12.8 billion per ship (see Table 5).²⁰ The gap between the estimates has narrowed since the 2017 plan: The Navy's has increased by \$500 million per ship, and CBO's has dropped by \$200 million per ship. It is not clear why the Navy's estimates increased, but CBO's estimates fell mainly because the agency projects somewhat less growth in real costs of the shipbuilding industry in future years.

Submarines

Under the 2019 shipbuilding plan, submarines would consume the lion's share of shipbuilding funds over the next 30 years—almost half of the amount needed for new-ship construction (see Table 6). The Navy currently operates 14 Ohio class ballistic missile submarines, 4 Ohio class guided missile submarines (SSGNs) modified from the SSBN version, and 50 attack submarines of several classes. Over the next three decades, the Navy plans to buy 12 new SSBNs, with the first purchase occurring in 2021. In a major departure from the last five shipbuilding plans, the Navy also wants to purchase 5 “large payload submarines” that are intended to replace the capability provided by the SSGNs that will be retired in the mid- to late 2020s. It also plans to buy 60 new attack submarines, including 30 Virginia class submarines that will carry more weapons than existing Virginias and 30 attack submarines of a new, advanced design. Production of those ships is set to begin in 2034.

20. CBO's estimate of the total costs for aircraft carriers over the 30-year period—\$86 billion—also includes funds appropriated for 2019 and budgeted through 2023 for the CVN-80. That amount excludes funding for the carrier that the Navy would order in 2048, but that would not be appropriated until 2049 or beyond.

Ballistic Missile Submarines. SSBNs, which carry Trident ballistic missiles, constitute the seabased component of the United States' strategic nuclear triad. (The other two components are landbased intercontinental ballistic missiles and strategic bombers.) The cost of the 12 Columbia class submarines included in the 2019 shipbuilding plan is one of the most significant uncertainties in the Navy's and CBO's analyses of future shipbuilding costs. Under the 2019 plan, the first Columbia would be purchased in 2021, although advance procurement funding started in 2017 for items with long lead times. The Navy would purchase a second Columbia class submarine in 2024 and then 1 per year from 2026 to 2035 (see Figure 4 on page 10).²¹

The Navy currently estimates that the first Columbia would cost \$13.2 billion in 2018 dollars and that subsequent ships would have an average cost of \$6.6 billion. The implied total cost for the 12 submarines is \$85 billion, or an average of \$7.1 billion for each ship (see Table 5). The Navy estimates that research and development costs would amount to \$13 billion, bringing the total acquisition cost to \$98 billion. The Navy's current estimate of costs for the Columbia class is greater than its estimate for the 2017 plan because it is the only shipbuilding program in the 2019 plan that includes real cost growth in the naval shipbuilding industry.²² That adjustment was required as part of the Department of Defense's approval of the Columbia class to Milestone B status, an important marker in the evolution of a major defense procurement program.²³

According to the Navy's estimate, the cost per thousand tons for the first Columbia would be 14 percent less than that of the first Virginia class attack submarine—an improvement that would affect costs for the entire new class of ballistic missile submarines. The Navy anticipates

21. For additional information, see Ronald O'Rourke, *Navy Columbia (SSBN-826) Class Ballistic Missile Submarine Program: Background and Issues for Congress*, Report for Congress R41129 (Congressional Research Service, updated August 7, 2018), <https://crsreports.congress.gov/product/pdf/R/R41129> (1.6 MB).

22. For further explanation, see Congressional Budget Office, *An Analysis of the Navy's Fiscal Year 2017 Shipbuilding Plan* (February 2017), p. 26, www.cbo.gov/publication/52324.

23. It is not clear whether DoD will require this change for other new shipbuilding programs as they get under way.

Table 5.

Comparison of the Navy's and CBO's Estimates for the Construction of Major New Ships Under the Navy's 2019 Plan

Billions of 2018 Dollars

	Number of New Ships Purchased	The Navy's 2019 Plan (2019–2048)				Memorandum: Average Costs per Ship Under the 2017 Plan	
		Total Costs per Class		Average Costs per Ship		Navy's Estimates	CBO's Estimates
		Navy's Estimates	CBO's Estimates	Navy's Estimates	CBO's Estimates		
CVN-78 Gerald R. Ford Class Aircraft Carriers	7	85 ^a	86 ^a	12.4 ^a	12.8 ^a	11.9	13.0
SSBN-826 Columbia Class Ballistic Missile Submarines	12	85 ^b	93 ^b	7.1 ^b	7.7 ^b	6.7	7.6
Large Payload Submarines	5	32 ^c	34 ^c	7.0 ^c	7.6 ^c	n.a.	n.a.
SSN-774 Virginia Class Attack Submarines With VPM	30	87	93	2.9	3.1	3.1	3.2
SSN(X) Future Attack Submarines	30	93	165	3.1	5.5	3.6	3.6
DDG-51 Flight III Arleigh Burke Class Destroyers	29	46	53	1.6	1.8	1.8	2.0
Future Large Surface Combatants	47	74	108	1.6	2.3	2.0	2.4
FFG(X) Frigates	20	16	22	0.8	1.1	0.7	0.7
Future Small Surface Combatants	36	27	43	0.7	1.2	0.6	0.8
LHA-6 America Class Amphibious Assault Ships	8	24	29	3.1	3.9	3.6	4.1
LPD-17 Flight II San Antonio Class Amphibious Ships	13	19	24	1.5	1.9	1.6	1.7
LPD-17 Replacements	7	15	18	2.2	2.6	2.3	2.7
T-AO-205 John Lewis Class Oilers	18	9	10	0.5	0.5	0.5	0.6
T-AKE(X) Replenishment Ships	9	6	8	0.7	0.9	0.8	0.9

Source: Congressional Budget Office, using data from the Department of the Navy.

Amounts shown in this table exclude funding for research and development.

Unlike Table 1, this table excludes 1 littoral combat ship and 29 support ships of various types.

CVN = nuclear-powered aircraft carrier; DDG = guided missile destroyer; FFG(X) = guided missile frigate; LHA = amphibious assault ship; LPD = amphibious transport dock; SSBN = ballistic missile submarine; SSN = attack submarine; T-AKE(X) = dry cargo ship; T-AO = oiler; VPM = Virginia payload module; n.a. = not applicable.

- In CBO's and the Navy's estimates for aircraft carriers, total costs per class include remaining funding for the CVN-80 but exclude some funding for the carrier the Navy plans to purchase in 2048 because that money would not be budgeted until 2049 or later. CBO's and the Navy's estimates of the average cost per ship include all funding for the CVN-81 and the 2048 carrier.
- In CBO's and the Navy's estimates for ballistic missile submarines, total costs include \$1.5 billion of funding appropriated in 2017 and 2018 for the first ship of the class. Both estimates exclude the research and development costs associated with the program, which the Navy estimates to be \$13 billion and CBO estimates to be between \$13 billion and \$17 billion.
- In CBO's and the Navy's estimates for large payload submarines, total costs exclude some funding for the fifth ship, which would not be budgeted until 2049 or later, but average costs per ship are calculated including those amounts.

lower costs per thousand tons for the Columbia because it plans to recycle, to the extent possible, the design, technology, and components used for the Virginia class. Furthermore, because ballistic missile submarines (such as the Columbia class) tend to be larger and less densely

built than attack submarines (like the Virginia class), the Navy maintains that they will be easier to build and thus less expensive per thousand tons. The Navy has stated, however, that there is a greater than 50 percent probability that the cost of the first Columbia and

Table 6.

**Total Shipbuilding Costs, by Major Category,
1989 to 2048**

	Historical, 1989–2018	CBO's Estimates Under the Navy's 2019 Plan, 2019–2048
	Average Annual Costs (Billions of 2018 dollars)	
New-Ship Construction		
Aircraft carriers	1.7	2.9
Submarines	4.1	12.8
Surface combatants	5.3	7.6
Amphibious ships	1.7	2.4
Logistics and support ships	<u>0.9</u>	<u>1.0</u>
Subtotal	13.6	26.7
Refueling of Nuclear-Powered Carriers and Submarines ^a	1.1	1.2
Other Items	<u>1.1</u>	<u>1.0</u>
Total	15.8	28.9
	Percentage of Average Annual Costs	
New-Ship Construction		
Aircraft carriers	11	10
Submarines	26	44
Surface combatants	33	26
Amphibious ships	11	8
Logistics and support ships	<u>5</u>	<u>4</u>
Subtotal	86	92
Refueling of Nuclear-Powered Carriers and Submarines ^a	7	4
Other Items	<u>7</u>	<u>3</u>
Total	100	100

Source: Congressional Budget Office.

Costs for new-ship construction exclude funds for refueling nuclear-powered aircraft carriers and for ship conversions, construction of ships that are not part of the Navy's battle force (such as oceanographic survey ships) and training ships, outfitting and postdelivery activities (including the purchase of smaller tools and pieces of equipment that are needed to operate a ship but that are not necessarily provided by the manufacturing shipyard as part of ship construction), and smaller items. The costs of the mission packages for littoral combat ships, which are not funded in the Navy's shipbuilding accounts, also are excluded.

a. CBO's estimates under the Navy's 2019 plan reflect only the costs of refueling aircraft carriers. Historically, the refueling of nuclear-powered submarines was also included in the Navy's shipbuilding accounts, but in 2010, the Navy transferred that funding to other accounts.

subsequent ships of the class would exceed its estimates, and CBO estimates costs that are about 9 percent greater than the Navy projects.

The costs of lead ships of new classes of submarines built in the 1970s and 1980s provide little evidence that ballistic missile submarines are cheaper by weight to build than attack submarines (see Figure 9). The first Ohio class submarine was more expensive to build than the lead ships of the two classes of attack submarines built during the same period—the Los Angeles and the Improved Los Angeles. (The design of the Improved Los Angeles included the addition of 12 vertical-launch system cells.) In addition, the average cost-to-weight ratio of the first 12 or 13 ships of the class was virtually identical for the Ohio, Los Angeles, and Improved Los Angeles classes.

Although the cost by weight of lead ships for submarines had grown substantially by the 1990s, there was still little evidence that submarine size affected the cost per thousand tons. The first Virginia class submarine, which was ordered in 1998, cost about the same by weight as the first Seawolf submarine even though the Seawolf is 20 percent larger and was built nine years earlier.

The difference between the Navy's and CBO's estimates is smaller than in earlier years, mostly because of the change in the way the service calculated its estimate. CBO estimates that purchasing the first Columbia class submarine would cost \$13.6 billion in 2018 dollars, \$0.4 billion more than the Navy estimates. Estimating the cost of the lead ship of a class with a new design is particularly difficult because of uncertainty about how much the Navy will spend on nonrecurring engineering and detailed design. CBO estimates that, all told, 12 Columbia class submarines would cost \$93 billion, or an average of \$7.7 billion each—a half billion more per submarine than the Navy estimates. That average is based on the \$13.6 billion estimated cost of the lead submarine and an average cost of \$7.1 billion estimated for the 2nd through 12th submarines. Research and development would cost between \$13 billion and \$17 billion, CBO estimates.

Overall, the Navy expects a 14 percent improvement in the cost-to-weight ratio of the Columbia class compared with the first 12 submarines in the Virginia class. Given the history of submarine construction, however, CBO is less optimistic than the Navy. CBO estimates that the

Navy will realize a 6 percent improvement, stemming in part from the projected savings attributable to the concurrent production of the Columbia and Virginia class submarines.

The costs for the Columbia class submarines could be lower than the Navy and CBO project, depending on the acquisition strategy. The Navy is purchasing the submarines through the National Sea-Based Deterrence Fund, which was established in the Carl Levin and Howard P. “Buck” McKeon National Defense Authorization Act for Fiscal Year 2015 (Public Law 113-291). The Congress appropriates money for the program in the Navy’s main shipbuilding account, and then DoD transfers money into the fund. The Navy could realize savings from special procurement authorities associated with that fund, such as the ability to purchase components and materials for several submarines, and possibly for other ships, at the same time. Further savings could be considerable if, for example, lawmakers authorized the Navy to use a block-buy strategy—an approach it has used with other types of ships. A block-buy strategy allows the Navy to purchase a group of submarines over a specified period (effectively lowering the price of the ships by promising a steady stream of work for the shipyards) and to buy components and materials for the submarines in optimal amounts that minimize costs (known as economic order quantities).²⁴ One disadvantage of the strategy is that if lawmakers later decided not to build all the submarines, materials that were purchased for the unbuilt ships might go unused. A block-buy strategy might also leave the Congress with less flexibility to change procurement plans or to purchase fewer submarines if lawmakers did not approve of how the program was progressing.

Costs for the Columbia class submarines could, however, exceed both the Navy’s and CBO’s estimates. The new SSBN would be the largest submarine that the United States has ever built. It is expected to reuse some technology and components from the Virginia class submarine, but it would also include many new

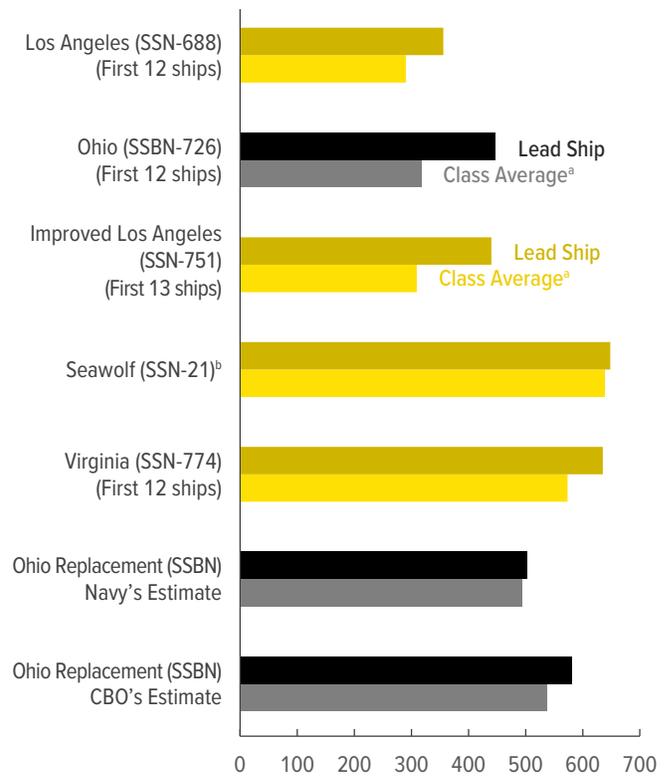
24. For more information on block-buy and multiyear procurement authority acquisition strategies, see Ronald O’Rourke and Moshe Schwartz, *Multiyear Procurement (MYP) and Block Buy Contracting in Defense Acquisition: Background and Issues for Congress*, Report to Congress R41909 (Congressional Research Service, updated July 31, 2018). The potential cost savings from block buys and purchasing materials in economic order quantities are not included in either the Navy’s or CBO’s estimate.

Figure 9.

Cost per Thousand Tons for Various Classes of Submarine, by Lead Ship and Class Average

Millions of 2018 Dollars

Historically, the cost per thousand tons has been about the same for attack submarines and ballistic missile submarines.



Source: Congressional Budget Office, using data from the Department of the Navy.

SSBN = ballistic missile submarine; SSN = attack submarine.

Cost per thousand tons of Condition A-1 weight is analogous to lightship displacement (the weight of the ship without its crew, stores, ammunition, or fuel or other liquids) for surface ships.

- a. Data exclude costs for plans, which include nonrecurring engineering and detail design.
- b. Although 29 Seawolf class submarines were planned, only 3 were built.

elements, such as an all-electric drive system, an X-stern ship control system, a new missile compartment, and a nuclear reactor that is designed to last the entire 42-year service life of the submarine.

Large Payload Submarines. In contrast to the Navy's last 10 shipbuilding plans, the 2019 plan includes a submarine that would be similar to an SSGN, but which the Navy describes as a "large-diameter, next-generation payload-based submarine."²⁵ The ship would be capable of performing missions similar to those currently conducted by SSGNs and, in the future, by Virginia class ships with the Virginia payload module (VPM), as well as other missions. The first ship would be ordered in 2036, after production of the Columbia class ceased; thereafter, the Navy would purchase 1 ship every three years, for a total of 5 by 2048. The 2019 plan does not indicate the final inventory objective for these ships.

The Navy provides little information about the size and capabilities of the large payload submarine. CBO assumed that it would be based on the Columbia class hull with its missile tube section reconfigured to perform whatever missions the Navy might want and that other sections of the ship would receive the necessary equipment and modifications to support the payloads the submarine might carry. The Navy estimates that the cost of the 5 ships in the plan would average \$7.0 billion per ship; CBO estimates that they would cost \$7.6 billion per ship.

Attack Submarines. The 2019 shipbuilding plan calls for the Navy to buy 30 Virginia class attack submarines. Between 2019 and 2033, it would purchase 2 such ships per year. In 2034, the Navy would begin purchasing the ship's successor, designated the SSN(X), at the same rate, for a total of 30 by 2048.

Unlike ships of that class built in earlier years, the Navy expects to lengthen the hull of the Virginias that would be purchased under the 2019 plan to insert the Virginia payload module. The VPM would contain four large-diameter payload tubes, each of which could carry 7 Tomahawk missiles or other payloads such as unmanned underwater vehicles. That modification would increase the submerged displacement of the submarine by nearly 30 percent and would increase the number of the Virginia class submarine's Tomahawk-sized vertical-launch weapons from 12 to 40. (The submarines would be armed with approximately 25 additional weapons—

torpedoes and Tomahawks—in the torpedo room.) The Navy estimates that the 30 submarines scheduled to be purchased between 2019 and 2033 would cost about \$87 billion; CBO estimates that cost to be \$93 billion.

In contrast, CBO estimates much greater costs for the SSN(X) than the Navy does. The Navy expects to purchase the first SSN(X) in 2034. Whereas the 2017 shipbuilding plan reflected an assumption that the successor to the Virginia would be an evolved version of that ship and would have VPM capability, the 2019 plan envisions a submarine that is more capable than the Virginia in many respects but without VPM. Specifically, the Navy indicates that the next-generation attack submarine should be faster, stealthier, and able to carry more torpedoes than the Virginia class—similar to the Seawolf class submarine. CBO therefore assumed that the SSN(X) would be a Seawolf-sized SSN, which displaces about 9,100 tons when submerged, and would have an all-new design in keeping with the Navy's description of it as a "fast, lethal, next-generation attack submarine."²⁶

On the basis of those assumptions, CBO estimates that the average cost of the SSN(X) would be \$5.5 billion per submarine, whereas the Navy estimated the cost at \$3.1 billion per submarine. That difference amounts to \$72 billion and accounts for more than 40 percent of the difference between CBO's estimate and the Navy's estimate of shipbuilding costs under the 2019 plan. (Under the 2017 plan, the Navy's and CBO's estimates were similar, reflecting a shared set of assumptions about the size and capabilities of the submarine and using the Virginia as the basis of a design called the Improved Virginia.) The large difference between the Navy's and CBO's estimates under the 2019 plan suggests widely different assumptions about the submarine's size, capabilities, and design. As a result, its final capabilities and costs are highly uncertain.

Large Surface Combatants

The Navy's 2019 plan calls for the purchase of the same types of ships as the 2017 plan. Currently, the Navy's fleet has 66 DDG-51 destroyers, composed of three variants designated as Flight I, Flight II, and Flight IIA. Another 9 Flight IIAs and 4 Flight IIIs (an upgraded design) are under construction or have been authorized

25. Department of the Navy, *Report to Congress on the Annual Long-Range Plan for Construction of Naval Vessels for Fiscal Year 2019* (February 2018), p. 8, <http://tinyurl.com/y9s4pouj> (PDF, 979 KB).

26. *Ibid.*

for construction by the Congress. Between 2019 and 2029, the Navy plans to build 29 DDG-51 Flight IIIs (see Table 5 on page 19). The first ship in that new flight was authorized in 2017. In 2030, the Navy would buy the first of 47 large surface combatants of a new class, which is intended to replace the DDG-51s. Although those new ships were designated as destroyers in the past, the Navy does not offer any description or designation of the class in its 2019 plan.

The Navy is pursuing two other strategies to boost its inventory of large surface combatants. One is to modernize 7 of its 22 Ticonderoga class cruisers and thereby extend their service to 43 years, so they would remain in the fleet through 2037. (The other 15 would remain in the fleet through the end of their service life of 36 to 38 years.) If the Navy does not modernize those 7 ships, all of its cruisers will be retired by 2028. The other critical strategy, announced after the Navy's 2019 shipbuilding plan was released, is to keep all DDG-51 destroyers serving in the fleet for 45 years. The class was originally designed to serve for 30 years, but the Navy has gradually increased the planned service life of all DDG-51 flights to 35 or 40 years in recent shipbuilding plans. The 2019 plan would extend their service life further.

Extending the service life of the destroyers would be a sharp break from the Navy's past practice: 12 of the last 13 classes of destroyers and cruisers have been retired after serving for 30 years or less. In recent years, Spruance class destroyers and some Ticonderoga class cruisers have been retired after serving 25 years or less. The Navy retired those ships for various reasons: They had reached the end of their useful service life, they became too expensive to maintain, or they no longer had the combat capabilities needed to meet existing threats and modernization was not considered cost-effective.²⁷ If the Navy retired the DDG-51 class after just 30 years for similar reasons, it would need to purchase additional ships to achieve its inventory goal.

DDG-51 Flight III Destroyers. To meet combatant commanders' goal of improving future ballistic missile defense capabilities beyond those provided by

27. See the testimony of Eric J. Labs, Senior Analyst, Congressional Budget Office, before the Subcommittee on Seapower and Expeditionary Forces of the House Committee on Armed Services, *The Navy's Surface Combatant Programs* (July 31, 2008), www.cbo.gov/publication/20065.

existing DDG-51s—and to replace 15 Ticonderoga class cruisers when they are retired in the 2020s—the Navy plans to substantially modify the design of the DDG-51 Flight IIA destroyer to create a Flight III configuration. That modification would incorporate the new Air and Missile Defense Radar (AMDR), now under development, which will be larger and more capable than the radar on current DDG-51s. For the AMDR to operate effectively in the new Flight III configuration, however, the ships must have a greater capacity to generate electrical power and cool major systems.²⁸

With those improvements incorporated into the design of the Flight III and the associated increases in the ships' displacement, CBO expects that the average cost per ship over the entire production run would be \$1.8 billion in 2018 dollars—about 15 percent more than the Navy's estimate of \$1.6 billion. Costs could be higher or lower than CBO's estimate, however, depending on the eventual cost and complexity of the AMDR and the associated changes to the ship's design to integrate the new radar.

Future Large Surface Combatants. Like the Navy's 2017 shipbuilding plan, the current plan includes a future class of LSCs that is intended to replace the DDG-51 Flight I and II ships when they are retired in the late 2020s and 2030s.²⁹ The 2019 plan also does not specify whether that new ship would be a cruiser or destroyer or something else entirely.

Under the 2019 plan, production of the future class of large surface combatants would start in 2030. The Navy says that it would buy 47 of the new LSCs through 2048 at an average cost of \$1.6 billion—the same price as the Navy's estimate for the average cost of a DDG-51 Flight III ship and \$400 million less than what the Navy estimated for the same ship under the 2017 plan. (The Navy did not explain the large reduction

28. See Ronald O'Rourke, *Navy Aegis Ballistic Missile Defense (BMD) Program: Background and Issues for Congress*, Report for Congress RL33745 (Congressional Research Service, updated August 1, 2018), <https://crsreports.congress.gov/product/pdf/RL/RL33745> (1.8 MB), and *Navy DDG-51 and DDG-1000 Destroyer Programs: Background and Issues for Congress*, Report for Congress RL32109 (Congressional Research Service, updated July 31, 2018), <https://crsreports.congress.gov/product/pdf/RL/RL32109> (1.4 MB).

29. Those retirement dates are based on the Navy's assumption that all DDG-51 Flight IIAs will be modernized midway through their 45-year service life.

in its estimate between the two plans.) That estimate implies that the new LSC would be either a destroyer-sized ship with capabilities that represent only a modest improvement over the DDG-51 Flight III or a smaller ship with significantly improved capabilities based on new-design technologies.

The Navy's cost estimate for the future class of LSCs appears to be based on a modified version of the existing DDG-51. In contrast, CBO expects the new LSC to have a largely new design but be about the same size as the DDG-51 Flight III, which would make it consistent with the concept of a large surface combatant. A new design would probably be more expensive to build than a modified version of an existing ship. In fact, recent comments by the Navy's Director for Surface Warfare, Admiral Ron Boxall, appear to validate CBO's assumption. He stated that although the future LSC should have capabilities that are similar to or greater than those of the DDG-51 Flight III, the Navy has "maxed out that hull footprint" and is looking at "what we need a new hull to do."³⁰ The Navy may also want to purchase the first ship in 2023 rather than in 2030.

Thus, CBO projects that the future LSC would cost an average of \$2.3 billion, roughly 30 percent more than the Navy's projection. Over the 2019–2048 period, CBO estimates, the Navy would need \$108 billion in funding for the future LSC portion of the shipbuilding program—\$34 billion more than the Navy's \$74 billion estimate. That amount represents almost 20 percent of the \$170 billion overall difference between the Navy's and CBO's estimates for the total cost of the 2019 shipbuilding plan (see the Appendix). The great uncertainty about the ultimate size and capabilities of the future class of LSCs suggests that the true cost could differ substantially from both the Navy's and CBO's estimates.

Small Surface Combatants

Under the 2019 plan, the Navy envisions building 56 small surface combatants (SSCs)—frigates and replacements for littoral combat ships (LCSs)—by 2048. The 2016 force structure assessment left the goal for those ships at 52, but unlike the 2017 plan (which

would never have achieved the goal), the construction rate in the 2019 plan would achieve a force of at least 52 between 2036 and 2044, before falling a few ships short thereafter.

Littoral Combat Ships. The Navy plans to order its last LCS in 2019. With the fiscal year 2018 budget, the Navy has 32 of the ships—split evenly between two designs built by competing contractors—either already in its fleet or currently under construction. Because the ships are assumed to have a service life of 25 years, the Navy would need to begin procuring their replacements in 2031. The service planned to purchase 1 final LCS in 2019, but the Congress appropriated funds for 3 LCSs in 2019. Subsequent small surface combatants would be frigates and a replacement for LCSs that would presumably also be a new frigate or a similar ship.

Guided Missile Frigates. In 2017, the Navy announced it would design and build 20 guided missile frigates, designated as FFG(X), with the first ship purchased in 2020 and the last ship ordered in 2030. According to the Congressional Research Service, "Although the Navy has not yet determined the design of the FFG(X), given the capabilities that the Navy wants the FFG(X) to have, the ship will likely be larger in terms of displacement, more heavily armed, and more expensive to procure than the Navy's Littoral Combat Ships (LCSs)."³¹ Under the 2017 shipbuilding plan (which was released in 2016), the Navy envisioned a frigate program that would upgrade one or both of the Navy's LCS designs while keeping the cost of the upgrade relatively low. Subsequently, the service decided to increase some of the ship's capabilities with existing technologies—such as the ability to protect another ship from air attack and to have at least 16 vertical-launch system cells—and thus desired a full design and contract competition for the class. To participate, industry teams competing for the FFG(X) must have an existing design or ship or a "parent design" of another ship that can be adapted to the Navy's requirements. Ships with existing designs have a displacement between 3,000 tons and almost 7,000 tons.

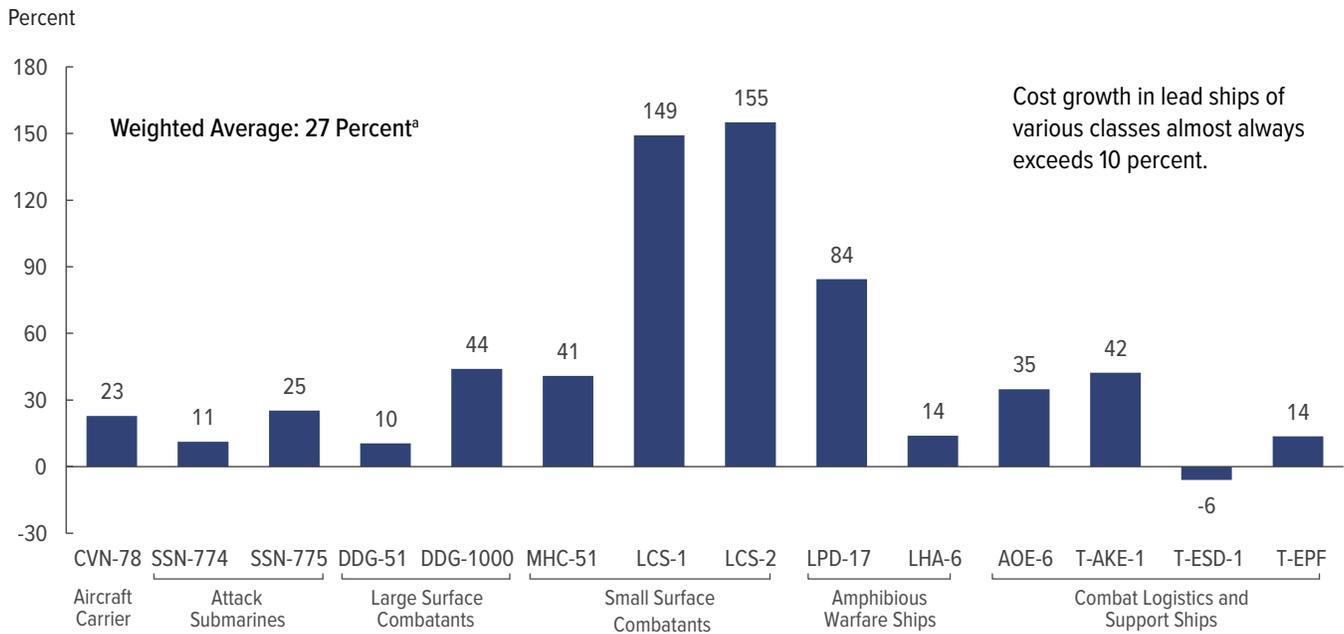
The Navy's cost goal for the program is currently set at \$1.2 billion in 2018 dollars for the first ship of the class

30. See Megan Eckstein, "Navy's Next Large Surface Combatant Will Draw From DDG-51, DDG-1000—But Don't Call It a Destroyer Yet," *USNI News* (August 28, 2018), <http://tinyurl.com/y7eufae8>.

31. See Ronald O'Rourke, *Navy Frigate (FFG(X)) Program: Background and Issues for Congress*, Report for Congress R44972 (Congressional Research Service, updated July 31, 2018), <https://crsreports.congress.gov/product/pdf/R/R44972> (2.4MB).

Figure 10.

Cost Growth in Lead Ships, 1985 to 2015



Source: Congressional Budget Office, using data from the Department of the Navy.

AOE = fast combat support ship; CVN = nuclear-powered aircraft carrier; DDG = guided missile destroyer; LCS = littoral combat ship; LHA = amphibious assault ship; LPD = amphibious transport dock; MHC = coastal mine hunter; SSN = attack submarine; T-AKE = ammunition cargo ship; T-EPF = expeditionary fast transport (formerly joint high speed vessel); T-ESD = expeditionary transfer dock (formerly mobile landing platform).

For most ships, CBO calculated cost growth using the first and last mentions of a ship in the books that accompany each year's budget: *Justification of Estimates, Shipbuilding and Conversion, Navy*. For AOE-6, MHC-51, EPF (formerly JHSV), and DDG-51, CBO relied on information papers provided by the Navy for the final estimates and on the Budget Appendixes for the years those ships were authorized.

a. CBO calculated the weighted average by summing the initial costs for all ships in the data set and comparing that to the sum of all final costs for the ships in the data set. The unweighted average cost growth is 45 percent.

and an average cost of \$800 million to \$950 million for the remaining 19 ships. Because the 2019 shipbuilding plan estimates an average cost of slightly more than \$800 million for all 20 ships—an amount at the very low end of the Navy's cost goal—actual costs would probably exceed the estimates. Historically, the costs of lead ships have grown by 27 percent on average over the Navy's initial estimates (see Figure 10). Taking into account all publicly available information, CBO assumed that the FFG(X) would displace about 4,700 tons, or the median point of the five proposed ship designs in competition for the program contract. As a result, CBO estimates the average cost of the FFG(X)s at \$1.1 billion each, for a total cost of \$22 billion, compared with the Navy's estimate of \$16 billion. Uncertainty about the frigate design makes that estimate particularly difficult to determine.

Future Small Surface Combatants. Under the 2019 plan, the Navy would begin purchasing 36 next-generation ships in 2031, which it currently refers to simply as future small surface combatants, to replace LCSs as they retire. In light of the many changes to the LCS and FFG(X) programs and their continuing evolution, it is not clear how large the new SSC would be, what capabilities it would have, or what its full range of missions would be. The Navy estimates that the new SSCs would cost an average of \$750 million, suggesting a ship in size and capabilities that is more equivalent to a frigate than to a littoral combat ship. CBO made the same assumption in displacement for the SSC that it did for the FFG(X), estimating the average cost to be about \$1.2 billion per ship. All told, CBO estimates that the new SSCs would cost \$43 billion, whereas the Navy projects a cost of \$27 billion.

Amphibious Warfare Ships

The Navy's inventory goal for amphibious warfare ships is 38. That proposed force would consist of 12 America class LHA or Wasp class LHD amphibious assault ships, 13 San Antonio class LPD amphibious transport docks, and 13 replacements for the Navy's LSD dock landing ships. To achieve that goal, the 2019 plan calls for buying 8 LHA-6s, at a rate of 1 every three or four years, starting in 2024, to replace LHD-1 class amphibious assault ships as they are retired. It also calls for purchasing 13 replacements for dock landing ships—the first in 2020, and then 1 per year between 2022 and 2031—to replace existing LSD-41s and LSD-49s as they are retired. The program, which used to be called the LX(R), was renamed the LPD-17 Flight II this year because the Navy plans to adapt the LPD-17 hull for the mission. Under the plan, the Navy would also start replacing the original LPD-17 class with a new class in 2040 and would buy 7 of the new ships by 2048.

Amphibious Assault Ships. The Navy estimates that the LHA-6 class amphibious assault ships would cost \$3.1 billion each, or \$500 million less per ship than the 2017 plan estimate. It is not clear why the Navy's estimate fell by more than 10 percent, especially after it also dropped by 10 percent between the 2016 and 2017 shipbuilding plans. The Navy estimated that the ship purchased in 2017 will cost \$3.8 billion. Under the 2019 plan, a seven-year gap separates that ship and the next one, slated to be purchased in 2024, which in CBO's estimation would effectively eliminate any manufacturing learning gleaned from building the first 3 ships of the class. As a result, CBO's estimate is higher than the Navy's, at \$3.9 billion per ship. Both CBO and the Navy assumed that all LHA-6 class ships authorized under the 2019 plan would have well decks. (A well deck is a large floodable area in the stern of an amphibious warfare ship that allows direct launching of amphibious vehicles and craft.) The first 2 America class ships did not have well decks.

Amphibious Transport Docks. The Navy estimates that the Flight II LPD-17s would cost \$1.5 billion, on average, and that the lead ship would cost \$1.7 billion to \$1.8 billion. The Flight II is a derivative of the LPD-17, which is much larger than existing LSDs—similar to the ways the DDG-51 Flight III is based on the Flight IIA of that class. (The hull and the main mechanical systems

are the same, but key systems related to the ship's mission are different.) To achieve its cost goal for the LPD-17 Flight II, the Navy plans to further alter the LPD-17 design and, perhaps, to change the way it buys them: The Flight II variant would have substantially less capability than the LPD-17 class, and the Navy may use block-buy or multiyear authority to purchase the ships.³² Such authority would commit the government to buy a group of ships over several years and thereby realize savings as a result of predictable and steady work provided to the construction shipyard, as well as to the vendors who provide parts and components to the shipbuilder. The authority would be similar to that provided for the Arleigh Burke class destroyers, Virginia class attack submarines, and LCSs.

CBO estimates that the LPD-17 Flight II class would cost an average of \$1.9 billion per ship. The agency used the existing LPD-17 hull as the starting point for its estimate and then adjusted the ship's size to reflect the reduced capability it expects for the Flight II. CBO's estimate reflects the assumption that the Navy would use multiyear or block-buy procurement authority to purchase the ships.

In the final six years covered by its current shipbuilding plan, the Navy would purchase 7 replacements for the LPD-17 class amphibious transport docks. CBO assumes that the replacement for the LPD-17 would be the same size and have roughly the same capabilities as the existing class—an assumption that the Navy also appears to have made in its 2019 plan. CBO estimates that the average cost of those ships would be \$2.6 billion. That estimate is higher than the Navy's estimate of \$2.2 billion largely because CBO factors real growth in the costs of labor and materials in the shipbuilding industry into its constant-dollar estimates and the Navy does not.

32. Although multiyear procurement and block-buy authority are broadly similar acquisition strategies, they are not identical. Block-buy authority is not regulated by statute, and it is more flexible (in that it is subject to less Congressional oversight) and less likely to carry cancellation penalties than multiyear procurement authority. But multiyear procurement authority allows the Navy to buy materials in large quantities for all ships covered under a given contract (and thus purchase materials in economic order quantities), whereas block-buy authority requires separate authorizations to purchase materials for more than one ship at a time.

Appendix:

The Difference Between the Navy's and CBO's Estimates for the Costs of New Ships

Each year, the Navy provides estimates of the costs of building each class of ship in its 30-year shipbuilding plan. The Congressional Budget Office also produces annual estimates. Table A-1 compares the two sets of estimates for the seven most recent 30-year plans. For the 2019 plan, two classes of ships account for about

60 percent of the \$170 billion difference between CBO's estimate (in 2018 dollars) of the total cost of the plan and the Navy's estimate: future large surface combatants and the future attack submarine. The former have been a significant source of estimating differences for all of the recent plans.

Table A-1.

Share of the Difference Between the Navy's and CBO's Estimates of Shipbuilding Costs, by Program

Percent	2012 Plan	2013 Plan	2014 Plan	2015 Plan	2016 Plan	2017 Plan	2019 Plan
CVN-78 Gerald R. Ford Class Aircraft Carriers	18	13	3	3	9	5	1
SSBN-826 Columbia Class Ballistic Missile Submarines	15	13	12	20	22	18	4
Large Payload Submarines	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	2
SSN-774 Virginia Class Attack Submarines	1	1	-1	3	3	7	4
SSN(X) Future Attack Submarines	3	4	-3	8	2	2	42
DDG-51 Flight III Arleigh Burke Class Destroyers	-7	11	7	11	12	9	4
Future Large Surface Combatants	41	34	58	38	29	26	20
LCS-1 Freedom Class Littoral Combat Ships	1	3	4	5	2	0	n.a.
FFG(X) Guided Missile Frigates	n.a.	n.a.	n.a.	n.a.	0	0	4
Future Small Surface Combatants	5	4	7	0	5	16	9
LHA-6 America Class Amphibious Assault Ships	7	5	5	3	3	5	3
LX(R) Dock Landing Ship Replacements	5	4	4	5	3	4	n.a.
LPD-17 Flight II San Antonio Class Amphibious Warfare Ships	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	3
LPD-17 Amphibious Warfare Ship Replacements	n.a.	n.a.	n.a.	n.a.	5	4	2
T-AO-205 John Lewis Class Oilers	0	0	1	1	3	4	0
Other	8	7	4	4	2	2	1
Total	100						
Memorandum:							
Difference in Billions of Dollars ^a	74	94	76	66	58	57	170

Source: Congressional Budget Office.

Numbers reflect the percentage that each ship program contributes to the total difference in cost between CBO's and the Navy's estimates for each plan. Positive values indicate instances in which CBO's estimate is higher; negative values indicate instances in which the Navy's estimate is higher.

CVN = nuclear-powered aircraft carrier; DDG = guided missile destroyer; FFG(X) = future guided missile frigate; LCS = littoral combat ship; LHA = amphibious assault ship; LPD = amphibious transport dock; LX(R) = dock landing ship replacement; SSBN = ballistic missile submarine; SSN(X) = future attack submarine; T-AO = oiler; n.a. = not applicable.

a. For each plan, the difference is expressed as a percentage in constant dollars from the preceding year. For example, the difference for the 2012 plan is calculated in 2011 dollars, the difference for the 2016 plan is calculated in 2015 dollars, and so on.



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About This Document

This Congressional Budget Office report was prepared as required by the National Defense Authorization Act for Fiscal Year 2012 (Public Law 112-81). In accordance with CBO's mandate to provide objective, impartial analysis, the report makes no recommendations.

Eric J. Labs prepared the report with guidance from David Mosher and Edward Keating. Raymond Hall produced the cost estimates with guidance from David Newman and Sarah Jennings (formerly of CBO). Bernard Kempinski (formerly of CBO) created the ship illustrations. Elizabeth Bass of CBO provided comments on the report, as did Karl Hasslinger of the Telemus Group and Bryan McGrath of the Hudson Institute. (The assistance of external reviewers implies no responsibility for the final product, which rests solely with CBO.)

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CBO continually seeks feedback to make its work as useful as possible. Please send any feedback to communications@cbo.gov.

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October 2018